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GENERAL INFORMATION | ABOUT HEWLETT-PACKARD

Although Hewlett-Packard products are manufactured throughout the United States and other parts of the world, the Hewlett-Packard field office or distributor in your area is best equipped to handle all your needs concerning products described in this catalog, and for parts and service on Hewlett-Packard products you already own. The worldwide listing of field offices, representatives, and distributors, current at the time of publication, is found on inside back cover.

Order by model number

Technical assistance in selecting equipment and preparing orders is available, without charge, from field engineers at all sales offices. When you place your order, please specify the catalog model number as well as the name of the product desired. Whenever you want special options or features, such as special color or non-standard power line voltage, ask your Hewlett-Packard field engineer about availability of these options, then, to prevent misunderstanding, include significant specifications and specific instructions in your order.

Many Hewlett-Packard instruments are supplied in cabinets along with easily attached hardware for direct mounting in standard 19-inch equipment racks. Others are available in two configurations: one a cabinet for bench use and the other with a 19-inch panel for rack mounting. Catalog listings indicate the availability of cabinet or rack mounting arrangements.

Pricing policy and delivery information

Prices appearing in this catalog are net prices prevailing at the time of printing and are FOB USA factory or warehouse. They apply only to domestic USA customers and do not include an import surcharge on applicable products. Such surcharge is to be added to the price shown. Prices prevailing at the time the order is received will apply. Please consult your nearest field sales office to confirm prices at your location and to obtain current delivery information. Customers outside the USA should consult their local Hewlett-Packard sales organization for price information. Although the illustrations and product information in this catalog were current at the time the catalog was approved for printing, Hewlett-Packard, in a continuing effort to offer the finest equipment available, reserves the right to change specifications, designs, models or prices without notice.

FOR CUSTOMERS IN USA

Where to send your order

Your order should be made out to the Hewlett-Packard Company and sent to the Hewlett-Packard office nearest you. Each field office has special communication channels to Hewlett-Packard manufacturing facilities to assure prompt and efficient handling of your order.

Shipping methods

Shipments to destinations in the USA are made directly from local factories or warehouses. Unless specifically requested otherwise, express or truck transportation is used, whichever is less expensive and most serviceable to you. Small items are sent parcel post. If fast delivery is needed, we gladly ship by air freight, air express, or air parcel post, when specified on your order, at prevailing rates. In many parts of the USA, a consolidated air freight service provides the speed of air transport at surface rates. Ask your field engineer for details.

Terms in the USA

Terms are net 30 days from invoice date. Leasing and extended financial terms are available. Your local Hewlett-Packard sales office will be pleased to discuss your requirements. Unless credit with Hewlett-Packard has already been established, shipments will be made COD or on receipt of cash in advance.

Economic stabilization act

Hewlett-Packard is a prenotification firm and prices for its products manufactured and sold in the United States are controlled by the Price Commission. Please direct any inquiries regarding these prices to Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304.

Quotations

Upon request, quotations including destination prices, will be furnished to you by your local Hewlett-Packard sales office.

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Pricing

Prices as listed in this catalog, unless otherwise noted, apply only to domestic USA customers; all other customers should consult their local Hewlett-Packard sales organization for price information.

Where to send your order

In many countries, your order can be placed directly with your local Hewlett-Packard distributor or representative. If there is none as yet in your area, your order should be placed directly with the office indicated for your part of the world.

Shipping methods

Shipments to customers outside the USA or Western Europe are made from the appropriate Hewlett-Packard facility by either surface or air, as requested. Sea shipments usually require commercial export packaging at a nominal extra charge.

Terms

Terms for orders from countries outside the United States of America which are placed with the Hewlett-Packard Company, Hewlett-Packard S.A., or Hewlett-Packard Inter-Americas, are irrevocable letter of credit or cash in advance, unless other terms have been arranged previously. Terms for orders placed with authorized Hewlett-Packard distributors are mutually determined between customer and distributor.

Quotations and pro forma invoices

FAS, CIF, C&F, etc. quotations or pro forma invoices, as well as exportation and importation assistance, are available on request from local authorized Hewlett-Packard sales offices or representatives.

ABOUT HEWLETT-PACKARD — A BRIEF SKETCH

Hewlett-Packard is one of the world's leading designers and manufacturers of electronic, medical, analytical, and computing instruments and systems. From its founding in 1939, the company has conscientiously followed its basic philosophy of offering only products representing significant technological advancements. The company's first instrument —an economically priced audio oscillator that was far more stable and easier to use than any other instrument available at the time—met this demanding criterion, as have the more than 2,000 Hewlett-Packard products that have followed.

The largest single segment of the company's business is the test instrumentation market. Hewlett-Packard electronic test and measuring instruments and systems are used by scientists, engineers, and technicians to accurately measure and record a wide variety of information-bearing signals. There are also Hewlett-Packard instruments that are used to provide known signals to passive devices so that test and measuring instruments can be utilized. Many Hewlett-Packard electronic instruments have built-in computing abilities. Most are designed to interconnect with computers, as well as with other test and measuring instruments, to develop automated test, measurement, and analysis systems.

As the company has grown, the product line has expanded to include a broad selection of data processing equipment, instruments and systems for medical diagnosis and monitoring, and electronic instrumentation for chemical analysis and measurement.

In the data processing field, Hewlett-Packard products include powerful pocket-sized electronic calculators; programmable electronic desktop calculators; small digital computers; computer systems for business, industry and education; and the first small-scale computer system with multi-programming and multi-lingual capabilities. Hewlett-Packard also manufactures peripherals such as disc memories, magnetic tape units, information input readers, and high speed plotters. Complementing this equipment is an extensive selection of Hewlett-Packard-developed software for computer programming.

For the medical profession, instrumentation includes medical computer systems, patient monitoring equipment, and precision instruments for diagnosis and research. In addition to instrumentation for cardiovascular measurement and monitoring, the company has entered other related medical fields when significant contributions are possible. Examples of this

are Hewlett-Packard's instrumentation line for perinatal care, and a family of products for automated pulmonary function test.

The company's analytical products include gas chromatographs, several types of spectrometers, and instruments for precise measurement of pressure and temperature.

To maintain its leadership in instrument technology, Hewlett-Packard invests heavily in new product development. Research and development expenditures traditionally average about 10 percent of sales revenue, and 1,500 engineers and scientists are assigned the responsibilities of carrying out the company's various R&D projects. As a result of this effort, about half of the company's current business is represented by products that were not in existence six years ago.

The company has also shown leadership in manufacturing techniques, developing many innovations that make it possible to offer high quality products at moderate cost. Engineering and production of solid-state devices, integrated circuits, and hybrid microcircuitry are prime examples. In many cases, specialized equipment is required for the production of these components as well as other unique parts. Often this equipment is designed and built in-house either because it is not available on the outside, or because it allows Hewlett-Packard an extra measure of control in maintaining the quality and performance expected of its products.

Hewlett-Packard is a well-established, multinational company that has controlled its growth so that expansion is financed generally from income on a pay-as-you-go basis. From its modest beginnings in Palo Alto, California, the company now has ten manufacturing plants in California, two in Colorado, and one each in Massachusetts, New Jersey, and Pennsylvania. Hewlett-Packard overseas manufacturing facilities are located in Scotland, German Federal Republic, France, Japan, and Singapore.

However, for the customer, Hewlett-Packard is no farther away than the nearest telephone. There are 60 field sales offices in the United States, and the company's products are marketed in over 100 countries abroad. All of these offices offer immediate assistance in solving measurement problems and providing advice on equipment selection, or with any help needed to keep equipment already in service in first-class operating condition. The field offices are staffed by trained engineers, each of whom has the primary responsibility of providing technical assistance and data to customers. A vast communications network has been established to link each field office with the factories and with corporate offices. No matter what the product or the request, a customer can be accommodated by a single contact with the company.

Hewlett-Packard is guided by a set of written objectives. One of these is "to provide products and services of the greatest possible value to our customers." Through application of advanced technology, efficient manufacturing, and imaginative marketing, it is the customer that the more than 20,000 Hewlett-Packard people strive to serve. Every effort is made to anticipate the customer's needs, to provide the customer with products that will enable more efficient operation, to offer the kind of service and reliability that will merit the customer's highest confidence, and to provide all of this at a reasonable price.

ABOUT HEWLETT-PACKARD | MEDICAL ELECTRONICS

An evolution for an involvement

Hewlett-Packard's service to the medical community is at the Medical Electronics Division (MED) in Waltham, Massachusetts, where more than 250 products for health care including diagnostic instruments, patient monitoring equipment, medical systems instrumentation, and computerized medical systems are manufactured.

Sanborn Company's (*which later merged with Hewlett-Packard*) first principal products were a water level recorder, a blood pressure gauge, the Benedict Metabolism Tester, the first string-galvanometer electrocardiograph, and the first portable ECG. These were followed by the present line of cardiological measurement instrumentation, which includes several models of electrocardiographs, heart sound instrumentation, and a vector-cardiography system.

In 1961, Sanborn became a division of Hewlett-Packard. The combined strengths of Sanborn, with its acknowledged leadership in understanding and providing for the needs of the medical community together with its experienced sales and service personnel, and Hewlett-Packard, with its leadership in development and support of electronic instrumentation, resulted in well-conceived, well-designed, and well-supported product lines.

MED's product lines

The product lines, which are listed in the Medical Instrumentation Catalog (5952-3525), of Hewlett-Packard's Medical Electronics Division (MED) currently contains more than 250 instruments comprising patient monitors, medical systems (for the operating room, cath lab, etc.), diagnostic instruments, and computerized medical systems. Current engineering efforts are expanding to telemetry for progressive coronary care monitoring, and monitoring equipment for new born intensive care units.

Central Station

780 series patient monitors

Continuous monitoring of coronary and critically-ill patients is undoubtedly among the most important innovations in patient care in the last decade. In response to this innovation, Hewlett-Packard designed the 780 Series of patient monitors for coronary care units, intensive care units, and recovery room monitoring.

The units of the 780 series electronically monitor various physiological phenomena such as ECG, pressures, temperature, and respiration. Monitoring is done on a round-the-clock basis; the patient is effectively never left alone. 780 bedside monitoring units are small, compact, self-contained instruments used to monitor various combinations of patient parameters. Patient data, transmitted by telemetry or cable, is displayed in analog or digital form on a variety of devices for convenient and effortless monitoring by the medical staff.

Because of the building block design of the 780 Series, units can be combined into an almost unlimited variety of systems to meet each hospital's specific monitoring needs. Other advantages of the building block approach are economy—cost reflects only those monitoring capabilities needed; and expandability—systems are easily enlarged to monitor more patients or more parameters per patient.

The Hewlett-Packard 780 Series also includes resuscitation capability. Defibrillation can be performed asynchronously for emergency treatment of ventricular fibrillation or the defibrillator can be used synchronously for the elective cardioversion of arrhythmias such as atrial fibrillation or atrial flutter. Pacing can be done in either the fixed-rate or demand (as-required-by-the-patient) mode.

8800 series medical systems

Late in the '60's the need for monitoring systems for clinical and research applications became apparent. This prompted Hewlett-Packard into developing the 8800 Series of Medical Systems comprising transducers, signal conditioners, recorders, and other display devices. The versatility of 8800 instrumentation permits customer configuration of systems for research, operating rooms, cath labs, and teaching applications.

The equipment provides substantial flexibility in meeting the requirements of the individual clinician and researcher. By combining standard sub-assemblies in building block fashion, virtually a limitless number of different configurations is possible. These range from two-channel systems in a small mobile cart, to highly sophisticated multichannel systems including chart recorders, oscilloscopes, numerical readouts, analog meters, and magnetic tape recorders.

Computerized Monitoring System

Diagnostic instrumentation

Hewlett-Packard has developed an extensive group of instruments primarily for clinical applications. These instruments monitor and/or display ECGs, VCGs, heart sounds, simultaneous fetal ECGs and labor contractions, nerve conduction and muscle voltages, and internal body structures. This was followed by our present single-channel electrocardiographs which provide all solid state circuitry and the most modern electronic technology available.

Electrocardiography

Hewlett-Packard offers two 3-channel electrocardiographs. One allows the nurse or physician to obtain a complete 12-lead electrocardiograph automatically in ten seconds. The second unit includes facilities for obtaining automatic cardiographs and/or provides a 3-channel display for electrocardiograph, phonocardiograph and pressure signals.

Electromyography

The Hewlett-Packard compact, 2-channel clinical electromyograph provides all of the sophisticated electronic gear necessary to do electromyography and nerve conduction studies in one package. It also utilizes a Hewlett-Packard developed variable persistence oscilloscope, which is unique to our instrument.

Pulmonary

Hewlett-Packard has met the growing need for pulmonary function testing by offering the Vertek Series of instrumentation. These include a Lung Function Analyzer which prints out test results within seconds, a Digital Pneumotach for research and clinical use, a Nitrogen Analyzer for accurate determination of nitrogen concentration in a gas sample, a Patient Respiratory Monitor for surveillance of patients on respirators or in ICU conditions and a Respiratory Function Analyzer mobile console which measures, plots, and digitally displays results of the five tests most commonly used in pulmonary function evaluation.

Fetal monitoring

Recently, a fetal monitoring instrument has been developed by our manufacturing facility in Boblingen, Germany, in conjunction with Dr. Konrad Hammacher of Dusseldorf. It combines both the phonocardiograph and fetal ECG techniques and allows the obstetrician to monitor fetal heart rate during the last trimester of pregnancy, or at the time of labor, and compare it with recorded labor contractions. In this way, the number of Caesarean sections can be reduced and the baby can be continually monitored during the most traumatic time of labor. The idea of monitoring the fetus is not new, but instrumentation that will eliminate extransous noises and maternal heart sounds is, and all of this is combined in the new Cardiotocograph, which uses logic circuitry to eliminate heart sounds or other extraneous noises.

Computerized medical systems

One of the goals of Hewlett-Packard's Medical Electronics Division is to provide medical systems and support that allow the computer to be a time-saving, accurate tool of the physician and researcher. To implement this goal, the concept of staellite, or dedicated, computers has been developed. Separate small computers perform their functions in the various areas of the hospital—intensive care, cath lab, operating room, etc.—and, if desired, communicate with a larger machine containing patient files and billing information. Three total system packages (both hardware and software) are currently available for medical systems applications. They are the Computerized Catheterization Laboratory, the ECG Interpretive System and the Computerized ICU/CCU Monitoring System. Additional available software includes a set of 52 statistical programs (the "Stat-Pac") written for biostatistical applications.

Computerized cardiac cath lab

This package aids the physician by reducing the analog data obtained during the cateterization procedure to a useful set of calculated values such as heart rate, systolic and diastolic pressure values, pressure gradients, cardiac output, etc. At the conclusion of the procedure, a report is generated for inclusion with other patient documentation.

Pulmonary Testing

ECG interpretive system

A specially-developed operating system controls the user's choice of two programs for ECG analysis, Mayo or USPHS, each based on different diagnostic criteria and both widely field-tested. Designed for operation by an ECG technician, the system merges patient history cards with ECG records and prints history, ECG, and interpretation in less than one minute. Results can be printed at both the computer site and the ECG terminal location. The system also produces patient billing reports upon request.

ICU/CCU monitoring system

A computerized, integrated, hardware/software system for patient monitoring is currently being developed and tested at Peter Bent Brigham Hospital, Boston, Massachusetts. This system is modular in nature, making it easily adaptable to any monitoring situation. Application tasks include scheduled automatic sampling of signals from bedside monitors (ECGs, pressures, respiration, temperature); plotting trends on a scope; logging nurses notes; cardiac output by dye curve; pulse waveform analysis; arrhythmia monitoring in conjunction with a preprocessor; acid-base analysis; and generating patient summary reports at the end of each nursing shift.

Hewlett-Packard's abiding commitments

Responsible concern is not confined to creating designing and manufacturing medical instruments alone. Since the ultimate value of medical instruments to physicians and hospital personnel must be measured by intrinsic benefits, the administrative staff of Hewlett-Packard's Medical Electronics Division has spent hundreds of man-years developing a "total concept" package, existing from the earliest stages of a medical instrument's definition and continuing throughout the useful life of the product.

Currently the full-time responsibility of more than 100 Hewlett-Packard professionals, the total concept package comprises regularly scheduled training programs, complete publications complements, on-site calibration and checkout procedures, extensive sales and service capabilities, emergency service loaner equipment, and systems analyst and field engineering support.

ANALYTICAL INSTRUMENTATION
Gas Chromatographs and Spectrometers
For chemical analysis

Widely recognized as the nation's foremost supplier of electronic measuring instruments for the engineer, Hewlett-Packard is fast developing a similar position in analytical instrumentation for the scientist. Fully described in a separate Hewlett-Packard catalog "Analytical Instruments for Chemistry," these instruments are briefly characterized in these two pages.

Gas chromatographs

Although less than 20 years old, gas chromatography (GC) has taken over from classical and other instrumental methods the bulk of analytical work performed in laboratories around the world. There is an excellent reason for the revolutionary popularity of the gas chromatograph in analytical chemistry: no other method gets more accurate results, at greater speed, and for less cost.

For the scientist whose interest is the chemical analysis of unknown samples, Hewlett-Packard offers four basic types of gas chromatographs, a more complete line than is available from any other manufacturer in the world:

Series 7600A Chromatograph System, a fully automatic GC that takes over the traditional work of the chromatographer, from sample measurement and injection to the final report of the analysis. Operating completely unattended, it performs the GC analysis more accurately and reliably than a skilled technician, at a fraction of the operating cost.

Series 7620A and 5750B Research GC's, multiple-detector instruments that permit the highest possible level of performance for a great variety of analyses. They are designed expressly for the research laboratory that requires an extremely versatile instrument.

Series 5700A Laboratory GC, the most modern instrument on the market, available in a variety of configurations for dedicated applications. Its modular design makes possible the most economical GC at the highest performance level for laboratories that specialize in specific analyses such as drugs, pesticides, natural gas and air pollution.

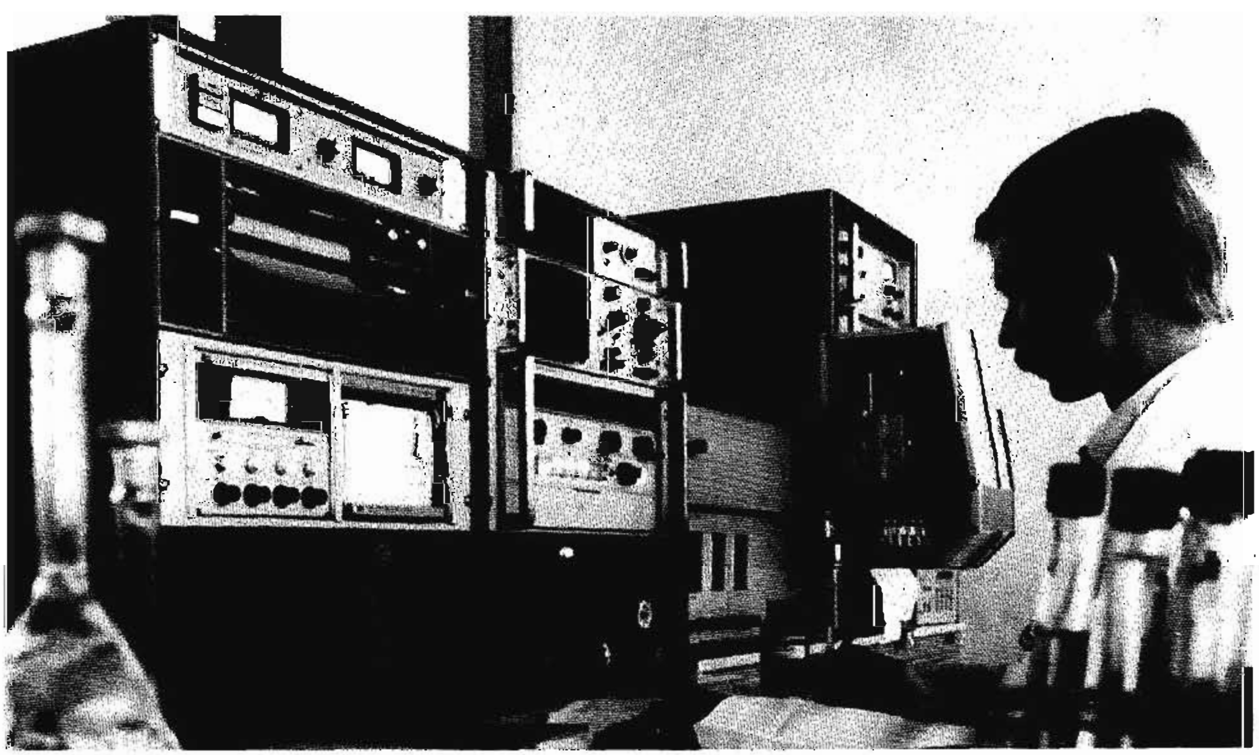
Series 7610A and 402B High-Efficiency GC's, whose large oven accommodates glass U-tube columns for the analysis of materials that are difficult to chromatograph. These instruments incorporate other design features that make them especially effective with biological samples and thermally sensitive or polar materials.

Model 5795B Preparative GC Attachment which converts analytical GC's to fully automatic small-scale preparative work. The 5795B is used to separate and collect pure components for further chemical studies, without interfering in any way with the gas chromatograph's analytical capability.

Model 7670A/7671A Automatic Sampler, an accessory that automates the measurement and injection of samples into a gas chromatograph. Operating unattended overnight and even over weekends, the 7670A/7671A reduces operating costs so significantly that even the smallest labs can justify its purchase.

Data handling

Since GC produces both qualitative and quantitative information on large



The gas chromatograph and mass spectrometer form the most powerful tool available to the scientist for rapid, positive and accurate analyses of unknown samples, especially when they are integrated with a computer as they are in the Hewlett-Packard GC/Mass Spec/Computer System.

numbers of complex samples in a very short time, its data output is so large that automatic methods for handling it are economical if not essential. Hewlett-Packard manufactures a variety of instruments and systems for automatic data handling to satisfy all budget levels:

3360A GC Data Processing System. Complete automation of the data handling process is achieved with the 3360A which can handle the output of up to eight GC's simultaneously, without intervention by the chromatographer. It prepares a full analytical report for each sample and is easily operated even by laboratory technicians who have literally no previous computer experience.

3370B Digital Integrator. An electronic integrator, the 3370B automatically measures the retention time and area of each peak on a chromatogram. It presents the data either on a built-in printer, on punched paper tape for use with time-share computers, or directly to a digital computer in real time.

Strip Chart Recorders. Several Hewlett-Packard recorders are available with special input circuitry for use in GC: Models 7127A, 7128A, 7143A/B, 680. All solid-state instruments, they offer a choice of one or two recording pens and five or ten-inch calibrated charts.

Hewlett-Packard manufactures a broad line of other data handling instruments including digital computers, programmable calculators, magnetic tape recorders and oscillographic recorders which are described elsewhere in this catalog.

Mass spectrometer

It is generally agreed among scientists that the most powerful tool for the qualitative and quantitative identification of unknown materials is the combination of a gas chromatograph and mass spectrometer. In the Hewlett-Packard system, these two instruments are fully integrated with a computer, further increasing their analytical power and operator convenience. All three components—gas chromatograph, mass spectrometer and computer—are manufactured and serviced world-wide by Hewlett-Packard.

The 5930A Mass Spectrometer can be operated either manually or automatically. In the automatic mode, the computer controls the operation of the spectrometer and accumulates the analytical data while it performs the necessary calculations. It does a complete mass scan every two seconds, fast enough to analyze every peak separated by the gas chromatograph, and stores all the analytical data for as many as 1000 scans on a single tape cassette. Later, the computer can search the cassette, find the scan of interest and type out a list of every peak, identifying each peak by mass number and relative abundance.

MRR spectrometer

Molecular rotational resonance spectroscopy (MRR) measures the absorption of microwave energy by molecules in the vapor state at low pressures. The technique has been widely used in fundamental molecular research for a number of years. With the introduction of the 8460A MRR Spectrometer, which is easy to use and more versatile than previous instrumentation, the technique has been extended to the analysis of complex gas mixtures, especially in air pollution studies and quantitative mixture determinations.

Microwave absorption occurs in any molecule that has a permanent dipole moment. The absorption pattern, or MRR spectrum, consists of sharp individual lines which always occur at the same frequencies regardless of sample composition and total pressure. Measurement resolution is so high that molecular conformers and non-radioactive isotopes can be separately identified. Compounds of molecular weight up to 350 can be measured. Impurities do not interfere and no sample preparation is required.

ESCA spectrometer

Electron spectroscopy for chemical analysis (ESCA) is a relatively new technique for measuring the binding energies of core and valence electrons in atoms and molecules. It has great potential in both structural and analytical chemistry, with applications in the study of surface chemistry, oxidation states, molecular structure and chemical analysis generally.

The HP 5950A ESCA Spectrometer advances the state-of-the-art in some extremely significant ways. It incorporates an X-ray monochromator and dispersion-compensated electron optics, each an entirely unique technological break-through. When combined with the 5950A's position-sensitive detector, these design features serve to eliminate the line-width of the exciting radiation without introducing any slits in the spectrometer. The result is an instrument that can be operated under optimum conditions of both sensitivity and resolution at all times.

The main performance characteristics of the 5950A include freedom from background and freedom from satellites as well as greatly improved resolution and sensitivity.

CHN analyzer

The Model 185B Carbon Hydrogen Nitrogen Analyzer performs a complete elemental analysis of organic materials simultaneously and automatically in less than 10 minutes. The 185 has gained considerable acceptance among microchemists, because of its ability to perform, even under difficult circumstances, elemental analyses whose accuracy is well within the accepted allowable error of ±0.3%, at a speed advantage of 4 to 8 times over classical methods.

Molecular weight instruments

A polymer solution invariably consists of a number of different molecules of different chain lengths and weights. It is often useful to the polymer chemist to make different kinds of molecular weight determinations because each gives him a better idea of the actual molecular weight of the sample and also tells him something of the distribution of the type of molecules in his sample.

Hewlett-Packard offers the polymer chemist a choice of two instruments to help him make fast and accurate molecular weight determinations of all sizes of molecules: Model 302B Vapor Pressure Osmometer for number-average molecular weight determinations between 50 and 25,000; Series 500 Membrane Osmometers for the same type of determination between 10,000 and 1,000,000.

Quartz thermometer

The Model 2801A Quartz Thermometer measures absolute or differential temperature with a resolution of 0.0001° over the range −80 to +250°C. It employs a small quartz disc transducer that operates as a piezoelectric resonator for a sensor oscillator. The resonant frequency of the quartz crystal varies as the temperature in such a manner that the frequency of the sensor oscillator output signal is a linear function of temperature. Probe temperature is displayed as a direct digital readout in °C or °F. A BCD output is also provided for input to computers and other data handling systems.

ABOUT HEWLETT-PACKARD

DELCON TELEPHONE CABLE MAINTENANCE INSTRUMENTS

Hewlett-Packard's Delcon Division is dedicated to the development and manufacture of instruments for telephone cable plant maintenance. Of prime interest is the location of physical damage to the cable.

Fault location has become an especially acute problem in recent years as more cable is placed underground. Although better protected from the environment, the cable is subject to new dangers and the telephone craftsman is faced with locating damage hidden by several feet of earth. In addition, higher traffic density on cables and demands for higher quality transmission have placed more emphasis on cable reliability and quality.

From the standpoint of the cable maintenance supervisor, fault location problems can be divided into five categories:

1. Maintaining the integrity of pressurized cable systems. Since pressurization is a preventive measure to keep moisture out of the cable, it is essential that leaks be located and repaired quickly before more serious damage results.
2. Locating conductor faults before they become catastrophic. High resistance shorts and grounds are usually indicative of water in the cable, which, if not located and repaired quickly, can result in complete cable failure.
3. Locating catastrophic faults. Time and location accuracy are of the essence in these cases in order to return the cable to service quickly with a minimum of excavation.
4. Cable utilization. This problem becomes most apparent when most of the pairs in the cable have been assigned and it is no longer possible to pick up a "spare" pair to replace a faulty pair. Faults on abandoned pairs must then be located and repaired in order to more fully utilize the cable's capacity.
5. Cable path and depth determination. This information is necessary in conjunction with accurately locating the fault. It is also necessary for accurately marking the cable location to protect it from construction and excavation work being performed in the vicinity of the cable.

Delcon Division strives to solve these problems with instruments that are easily operated by non-technical personnel and that will withstand the rigors of the outside plant environment.

Ultrasonic leak detection

As pressurized gas escapes through an aperture it creates considerable noise in the ultrasonic region of 36 to 44 kHz. The Delcon Ultrasonic Translator Detector (such as Model 4905A) detects this characteristic sound with a sensitive, directional Barium Titanate microphone and translates the signal to audio by mixing it with a 40 kHz local oscillator signal. The audio signal is then amplified and monitored on a speaker and level meter.

To detect leaks in aerial cables, the craftsman merely scans the cable from the ground with the flashlight-size microphone, listening for the characteristic hissing sounds of a leak. By simultaneously observing the level meter, he can "peak in" on the leak and determine its exact location. Pole mounted accessories are also available for closer scanning of the cable.

Leaks in ducted underground systems are located with a unique "Duct Probe" accessory. Consisting of a miniature microphone connected to a system of aluminum rods, the Duct Probe can be used to explore up to 500 feet into a cable conduit. The leak is thereby pinpointed precisely, permitting repair of the damage with a minimum of excavation.

Direct reading fault locators

Fault locators that provide a direct distance-to-fault reading in feet (or meters) have the benefit of relieving the craftsman of the drudgery of performing manual calculations. Locating faults becomes faster, requires less training and is less error prone than with manual bridge techniques.

The Model 4912F Conductor Fault Locator is a direct reading, automatic calculating bridge operating on the Varley principle. This instrument is designed to locate extremely high resistance shorts, crosses and grounds, such as might occur from minute amounts of moisture in plastic insulated cable (PIC). The 4912F is connected to an access point on the cable and the far-end of the cable is strapped to form a bridge configuration. The distance-to-fault result is obtained by a simple sequence of adjustments of the instrument controls. The 4912F is battery powered, light and compact. It is housed in a rugged fiberglass case and is designed to withstand the demands of field use.

Similar in construction and operation to the 4912F, the Model 4910F Open Fault Locator is designed to provide direct distance readings to open faults in paired telephone cable. The 4910F operates on a capacitance charge sampling principle. Since the capacitance per unit length of a pair is known for a particular type of cable, this capacitance can be related to the length of the pair. The 4910F measures this length by charging the pair capacity, C_L, with a known dc voltage; transfering a portion of this charge to a standard capacitor, C_S, in the instrument for a given length of time; and measuring the charge across C_S with a voltmeter calibrated in feet. This entire sequence is performed automatically by the 4910F, providing an answer in just a few thousandths of a second.

Tone type fault locators

The tone type locator, such as the Model 4904A, places a 990 Hz signal on the faulted circuit which is traced by an inductive pickup coil and a sensitive tuned receiver. At the point of the fault, the signal drops in level, thereby indicating the exact physical location of the fault. The tone locator also has the advantage of being able to precisely trace the path of the cable and, by triangulation, determine its depth at any point. The tone locator system is designed such that only the transmitted signal is detected, so that interfering signals (such as power line harmonics) do not interfere with the measurement. Output power of the transmitter is kept low to prevent interference with other working circuits in the cable and to prevent "carry-by" of the signal beyond the fault.

MORE INFORMATION ON DELCON PRODUCTS

U.S.A. Customers: Delcon products are sold directly to the customer from the manufacturing division. Please direct all orders and inquiries to:

Hewlett-Packard Company
DELCON DIVISION
690 E. Middlefield Road
Mountain View, California 94040
Telephone (415) 969-0880

Customers outside the U.S.A.: Orders should be directed to your local Hewlett-Packard distributor or representative. See inside rear cover.

GENERAL PURPOSE INTERFACE BUS
For programmable instruments and instrumentation systems

DIGITAL INSTRUMENT INTERFACE BUS

General-Purpose Instrument Interface Bus

Instrumentation systems require a good communication link among system elements in order to solve measurement problems in a useful way. This need applies equally to systems ranging in size from the small bench top configuration to large computer-controlled instrumentation systems. The rapid increase in the use of automated systems, remote data acquisition systems, and timeshare techniques, to name a few applications, have all helped to increase the demand for improved communications within and between instrumentation systems. In addition, new programmable instrumentation operating at higher rates, with an increased percentage of programmable features, suited to remote (out of visual and physical contact) operation have similarly contributed to the demand for better ways of putting systems together. What then can be done to assist both the manufacturer and user of programmable instrumentation to simplify the instrument interface problem and reduce the costs involved in such a way as to not jeopardize either instrument or system performance?

What Is An Interface?

The exchange of digital messages (address, basic, control, and status data) between instruments involves much more than the basic hardware elements of cables, connectors, and interface circuit devices. The repertoire of messages to be communicated, the method of exchanging these messages between points in the network, and the interface structure necessary to manage an unambiguous flow of messages are all important. The codes and formats, assertion convention (polarity or logic assignment of binary data), control techniques, timing guidelines, to name a few parameters, are all important. Effective communication demands that a complete digital interface system be defined taking into consideration all of these parameters. Only then will interproduct compatibility be accomplished with ease, reliability, and reasonable cost.

A General-Purpose Interface Bus

A practical interface for instrumentation systems must be capable of interconnecting measurement, stimulus, display, storage, and processor products. Any or all of these product types may find use in instrumentation systems. Recent advances in microcircuit device technology, the advent of intelligent instruments (internal microprocessors for instrument control and data reduction), and the necessity to be compatible with many serially interfaced devices (e.g., word serial processors, byte serial paper and magnetic tape units, bit serial common carrier links) have all contributed to making feasible this General-Purpose Interface Bus.

Basic Network: The system accommodates up to 15 devices (i.e., instruments, data peripherals, etc.) interconnected over one contiguous bus interface. Each device is fitted with an interface connector and interconnected to other devices via a single passive cable. This interface system utilizes an 8-line Data Bus, a 3-line Transfer Bus and 4 additional Control Bus lines to manage the flow of information over the Data Bus and Transfer Bus. Figure 1 illustrates this communication network. Fifteen assigned signal lines, one reserved signal line, 7 ground lines, and one overall shield, make up the entire 24-line interface. Information flow over the Data Bus is exchanged in byte serial fashion with each byte being transferred from one *talker* to one or more *listeners*. The data is carried bi-directionally (i.e., data is both transmitted and received, at different times, on the same signal lines to a given device). Data formats may be variable in length to suit the needs of a wide variety of products. Each message (one to N bytes) is preceded by an address byte to identify the specific location to which the message is addressed. Measurement data of a numeric nature is typically formatted in free-field form (e.g., 456, +123.45, 987E-6). Data is exchanged asynchronously over the interface at rates up to 1 megabyte per second as a function of the type of interface circuit device (TTL-compatible) used.

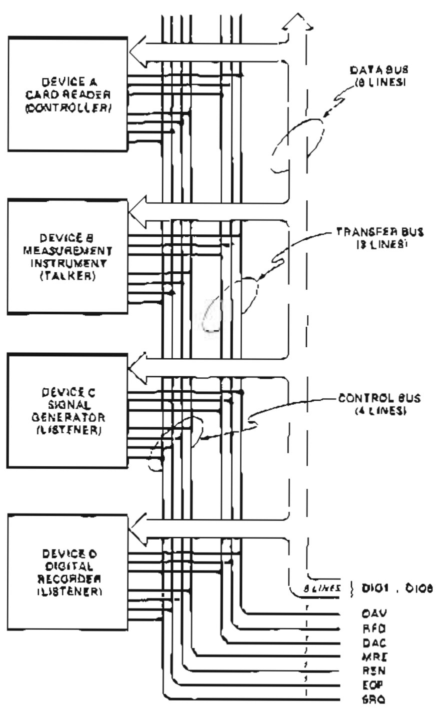


Figure 1. Typical Bus System Communication Network.

Bus Signals: Each of the fifteen assigned signal lines has been named for its basic function in the interface system. An abbreviated description of each signal line indicates its primary function. The Data Input Output (DIO1...DIO8) lines carry information (address, basic, control, and status data) between devices, typically encoded with low-state assertion. Any code, up to 8 bits, may be used; however, the ASCII code is preferred. A Data Valid (DAV) signal indicates data on DIO1-DIO8 carries a valid message and may be transferred across the interface. One Ready for Data (RFD) line indicates the readiness of bus-connected devices to accept data, and a Data Accepted (DAC) line indicates acceptance of data by devices on the bus. A Multiple Response Enable (MRE) line identifies whether information on the DIO lines is to be directed to specific devices or common to all devices. If the data is common to all devices, it contains either address or command data. A Remote Enable (REN) line signals to all bus-connected devices that they should respond to either their front panel switch setting or communicate over the interface connector. End Output (EOP) enables whichever device is in control of the system to halt all communications over the bus. One Service Request (SRQ) line permits devices on the bus to alert the system controller of the need for further action (e.g., status data reporting, next event in programmed sequence, etc.)

Bus Management: Each byte of data is transferred across the interface by means

GENERAL PURPOSE INTERFACE BUS
For programmable instruments and instrumentation systems

of the Transfer Bus. These three lines combine their actions to form an interlocked *handshake* across the interface, the purpose of which is to assure that the slowest responding device on the bus receives the message. This technique is particularly useful when all devices are being addressed when the communication path is being set up or when one device is talking to two or more listeners simultaneously. Devices are addressed via the DI01-DI05 signal lines. Each device may be addressed specifically as a *talker* or *listener*. Address and command data are sent with MRE in the Low state. With DI06 and DI07 both in the High state, command data common to all devices (e.g., Device Clear Command) may be sent over the interface. Each device may gain the attention of the controller by pulling SRQ Low (a common wire-OR'd line) asynchronously to other action on the bus. When ready to respond, the controller then identifies which device needs attention and proceeds to carry on further dialogue with that particular device.

Physical Implementation: Driver circuits are typically open collector NPN gates, and receiver circuits TTL Nand gates. Messages are conveyed in the Low assertive state with one exception (the dedicated RFD and DAC lines). Low-state assertion implies that the High state ($\geq +2.4$ V) is a logical 0 and the Low state ($\leq +0.4$ V) is a logical 1. Each device is terminated with a unit load so that no additional circuits, terminations, or power supplies are required beyond the passive cables. Interconnecting cables are available in 3, 6, and 12 foot lengths for ease in assembling systems.

Bus Features

The interface bus system described in this section, and being implemented in a number of new Hewlett-Packard products, significantly increases interproduct compatibility. This interface system is intended to benefit design engineers, manufacturers, and customers alike. While not all characteristics or features of the bus system take on equal significance or priority as used in different applications, the following summary of key features outlines some of the more fundamental bus system qualities. The interface bus system:

- Enables the configuration of small, relatively low-cost bench top systems by means of simple interconnecting cables without imposing significant restrictions on individual instrument performance or cost.
- Aids the interconnection of a wide range of products required to complement and support programmable instruments including control devices ranging from simple card readers to complex processors.
- Enables greater system performance and flexibility by permitting an instrumentation system to be configured with more than one device capable of controlling the system, one at a time, and permits an unambiguous shift in control from one device to another.
- Recognizes the need for and permits translation of the interface to and from other, more specialized, interface environments.
- Enables asynchronous communication among two or more devices.
- Utilizes the commonly available and easily generated ASCII code as one of many permissible code forms.
- Allows changes in codes, data rates, and network communication paths to achieve an efficient system operation with direct communication between the affected devices.

One word of caution is in order. While this interface system goes much further than ever before in defining a standard interface, it does not guarantee instant systems or unqualified compatibility. Figure 2 illustrates an instrumentation system interconnected with the interface bus. It is believed this General-Purpose Interface System will help provide good interproduct compatibility in a straightforward, reliable, and cost-effective manner.

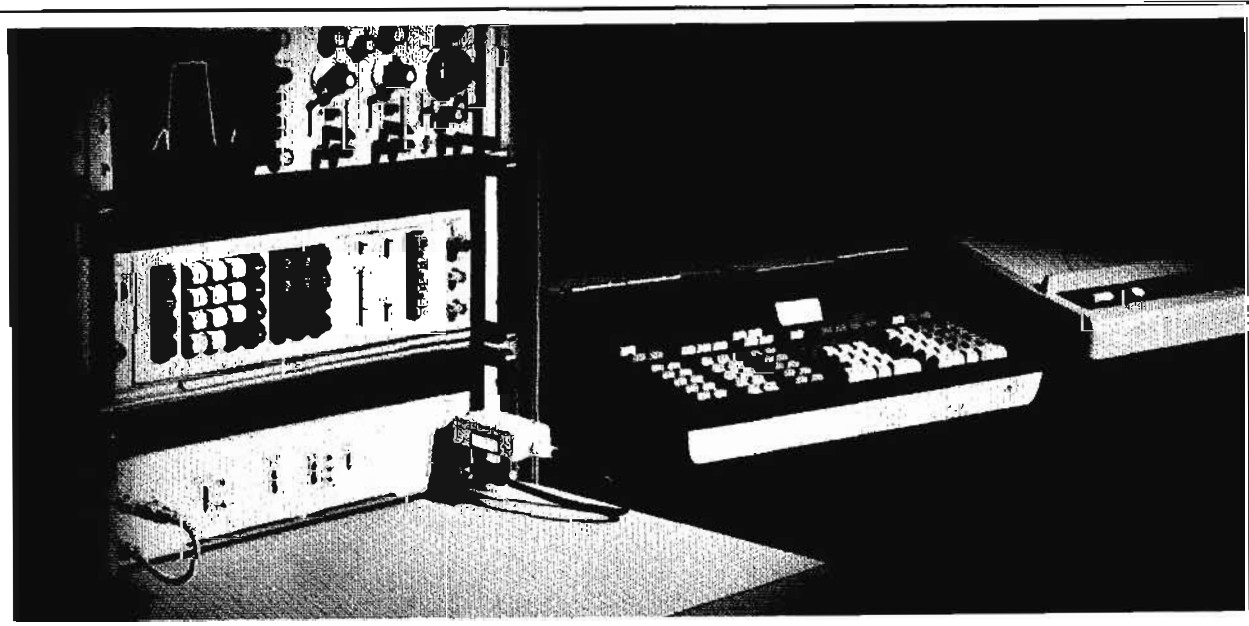


Figure 2. New Network Analysis System Utilizes General-Purpose Interface Bus.

WHAT YOU CAN EXPECT WITH YOUR H. P. EQUIPMENT

ABOUT HEWLETT-PACKARD

Warranty

All Hewlett-Packard products are warranted against defects in materials and workmanship. The period of coverage is specified in a warranty statement provided with each product. Hewlett-Packard will repair or replace products which prove to be defective during the warranty period. In some cases reference is made to a requirement for preventive maintenance. No other warranty is expressed or implied. Hewlett-Packard is not liable for consequential damages.

Certification

Products, materials, parts, and services furnished on this order have been provided in accordance with all applicable Hewlett-Packard specifications. Actual inspection and test data pertaining to this order is on file and available for examination.

Hewlett-Packard's calibration measurements are traceable to the National Bureau of Standards to the extent allowed by the Bureau's calibration facilities.

The Hewlett-Packard Quality Program satisfies the requirements of MIL-Q-9858, MIL-I-45208, and MIL-C-45662.

Assurance that your equipment will continue to perform as expected for years to come is provided by Hewlett-Packard's world-wide Customer Service organization. There is a Hewlett-Packard field office not far from you—you don't have to correspond with a factory several thousand miles away to get information, replacement parts, or service assistance when you need it. This customer service program is one of the major factors in Hewlett-Packard's reputation for integrity and responsibility towards its customers.

Customer Service Agreements

Your instrument maintenance needs in many cases may be handled most economically by entering into a Hewlett-Packard Customer Service Agreement. When you have a customer service agreement, Hewlett-Packard assumes your maintenance responsibilities for a basic annual charge, relieving you of the need for hiring your own trained specialist, for maintaining replacement parts inventories, and for doing the paperwork needed for maintenance scheduling.

Contact your nearby Hewlett-Packard field office for details.

Replacement Parts

Hewlett-Packard makes every effort to shorten spare parts delivery time and as a result, over 90% of the replacement parts orders are filled the same day they are received.

To sustain equipment operation in remote areas, or where equipment downtime is extremely critical, spare parts kits are available.

When ordering a replacement part, please specify the Hewlett-Packard part number listed in the table and give the complete name.

If circumstances require your ordering a part without specifying the part number, please include in your order the instrument model number, its serial number, a complete description of the part, its function, and its location in the equipment.

Repair Service

Help in maintaining your Hewlett-Packard equipment in first-rate operating condition is as close as a phone call to the nearest Hewlett-Packard field office. Whether you want to repair an instrument yourself, or send it to a Hewlett-Packard facility for repair, recalibration, or overhaul, your local Hewlett-Packard field office can offer a complete range of technical assistance.

Local repair facilities are backed up by Regional Repair Centers, located in major industrial areas around the world. The Regional Repair Centers have more sophisticated test equipment, factory-trained specialists, and a full line of replacement parts.

If your equipment installation is fixed, and if justified by the type of service required, Hewlett-Packard will perform service at your facility.

You have access to all of Hewlett-Packard's extensive service network through your local Hewlett-Packard field office.

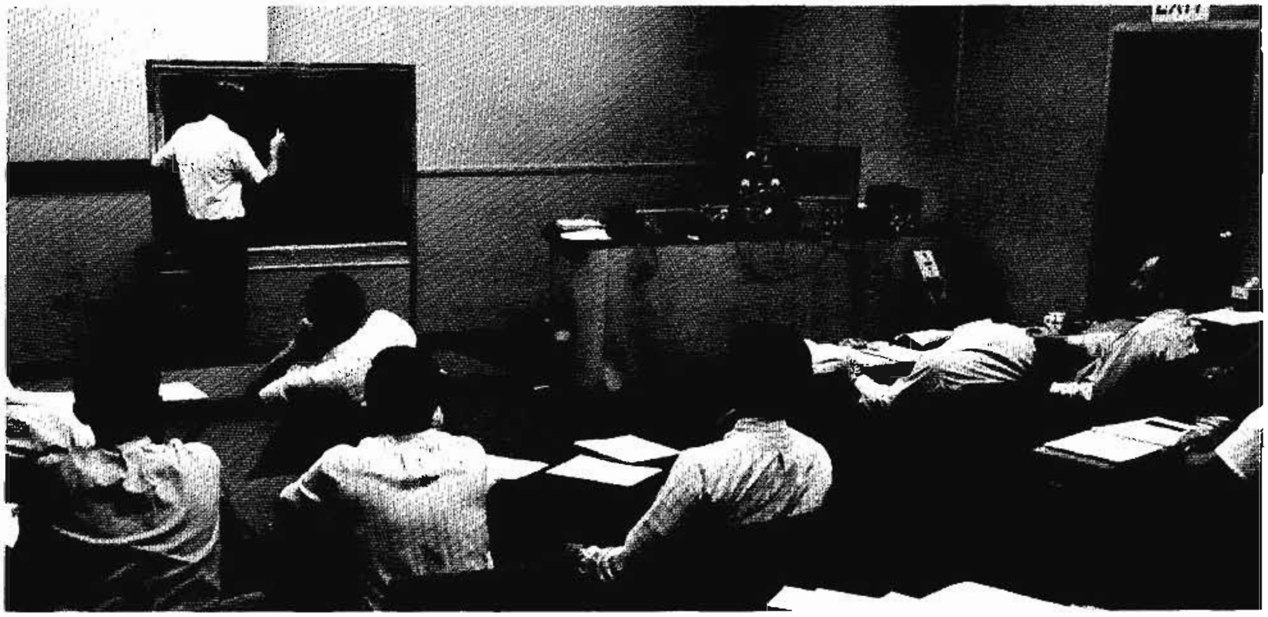
Service Publications

The Operating and Service Manual supplied with each Hewlett-Packard product contains maintenance, calibration, diagnostic and repair procedures, with trouble-shooting charts and complete circuit diagrams. All replaceable parts are listed. Extra manuals are available at reasonable cost from your nearby Hewlett-Packard field office. Most operating and service manuals with changes and service notes are now available on COSATI standard, positive microfiche.

New or special calibration procedures, instrument modifications, and special repair procedures are described in detail in the Hewlett-Packard Service Notes. This series of publications serves as a convenient means for updating Operating and Service Manuals.

Bench Briefs, a periodic newsletter, has servicing tips, new modifications and other suggestions to help repair and maintenance personnel get maximum performance from Hewlett-Packard instruments. It describes new Service Notes and other company publications as they become available. To become a regular subscriber, merely ask your local Hewlett-Packard field office to place your name on the mailing list.

TECHNICAL TRAINING



Part of the "extra value" which comes with each Hewlett-Packard product is our continuing commitment to provide Hewlett-Packard customers with useful training information in the areas of applications and service. In the past, this information has often been in the form of classroom seminars, either at your nearby Hewlett-Packard sales office or at one of our training facilities in California.

Now our capability is expanding by offering you both service and applications training via video tape. Video tape training is exceptionally convenient and readily available, ready for your own use at any time or any place, including within your own facilities.

Training in equipment operation and maintenance is easier with video tape because concepts are clearly visualized.

HP video tapes

A better way to learn

Effective. Hewlett-Packard has found that video tape is a highly effective training medium. Video tapes can convey more information in *less time,* and with *higher retention,* than even the best live instruction. Hewlett-Packard programs are professionally produced and are based on measurable instructional objectives. They consider what the student already knows, emphasize what he needs to know, and omit what he does not need to know. Many video tapes utilize *split-screen* techniques, allowing students to watch a procedure on one part of the screen while observing its *effect* on another part. Most Hewlett-Packard video tapes are *100% visualized,* as opposed to conventional, partially visualized video tape "lectures."

Flexible. With video tapes, you can *tailor* your training program to suit the many needs of your organization. You may select training programs for individuals with different backgrounds and specific needs, present effective programs to audiences of just one or hundreds, and offer a library of technical programs your staff members can easily consult on their own . . . for *new information* or for *refresher* purposes.

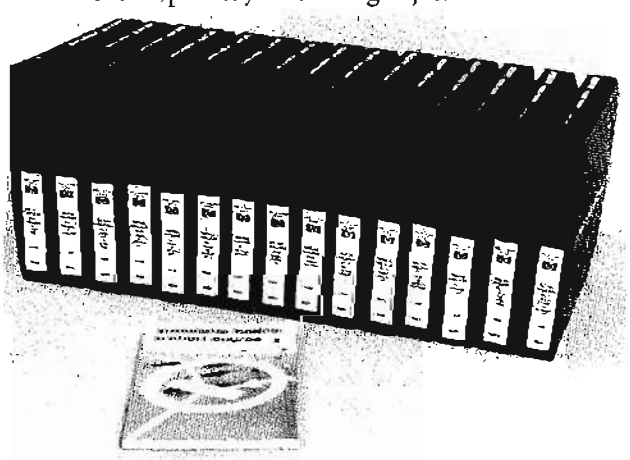
Faster. It has been our experience that Hewlett-Packard video programs *compress learning time* by a factor of 6-to-1. A video tape library also reduces the time needed to organize and schedule your training. You can schedule highly professional presentations anytime and anywhere, without arranging for outside instructors or juggling the detailed logistics that are often required for live training sessions. More effective training in one-sixth the time!

VIDEO TAPES
A Better Way to Learn

Video tape programs provide an efficient and convenient means of in-depth training which may be tailored to specific needs. The flexible medium has the ability to impart detailed information quickly and effectively, making it especially useful for technical training.

Convenient. Video tape programs come on small, *easy-to-file* reels of magnetic tape. Inexpensive playback equipment is easily operated by unskilled personnel. Programs may be viewed on small portable monitors or on full-screen TV sets. Video tapes can be quickly searched for specific information using "fast forward" or "fast rewind," and many recorders can stop on a single frame for more detailed study.

Time-Tested. All the video tapes offered in the Hewlett-Packard Videotape Catalog were developed to serve Hewlett-Packard's needs for a practical, low cost source of up-to-date training in a wide variety of subjects. Now, after having been tested in Hewlett-Packard training activities throughout the world, many of these video programs are available to help meet your training objectives.



A best seller

Practical Transistors, a 15-program series for training electronic service technicians, is one of the most effective and widely used video tapes courses of its kind.

The purpose of the series is to teach technical service personnel the truly practical aspects of transistor and other semiconductor circuitry. The programs avoid the use of complex mathematical equivalent circuits, and instead concentrate on presenting a clear and understandable look at the what, why and how of transistor circuits and the common techniques for troubleshooting them.

Throughout the tapes, ample use is made of demonstrations to compare measured with predicted results. Actual user experience has shown that the course is not only well received by technicians, but also creates a definite improvement in their troubleshooting and maintenance performance.

This Hewlett-Packard video tape course is in wide use throughout industry, colleges and universities, technical institutes, research organizations, vocational schools, and military training departments.

A supplementary textbook, plus a complete set of homework problems and answers, is included with the nine hours of video taped material.

TRAINING/VIDEO TAPES

VIDEO TAPES—A MINI INDEX *

Advanced Learning Modules

Each of these video tapes cover a single electronics measurement concept with a clarity and depth of understanding not found in texts or conventional classroom lectures. Unique, self-scoring quizzes are included.

Reflection Terms
Source VSWR
Transmission Lines
What's a dB?
Count Any Signal
Time Interval Measurements
Power Measurement

Computers & Peripherals

Digital Magnetic Tape Basics
HP Basic Computer Language
9300 Disc Memory: Theory
9300 Disc Memory Alignment
2895A Tape Punch Maintenance
2600A CRT Terminal Service

9820A Algebraic Language Calculator

9820A Calculator: Introduction
9820A Calculator: Peripheral Control

Calculator Service

9810A Calculator: Introduction to Servicing

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*Space permits only a representative sample of an index approaching 200 tapes. A complete *Index to Hewlett-Packard Video Tapes*, detailing titles, running times, order numbers and prices, is available free of charge from your local Hewlett-Packard sales office.

Laser Interferometer

5525A Laser Operation and Alignment

Instrument Fundamentals

Oscilloscope Basics

Troubleshooting Series

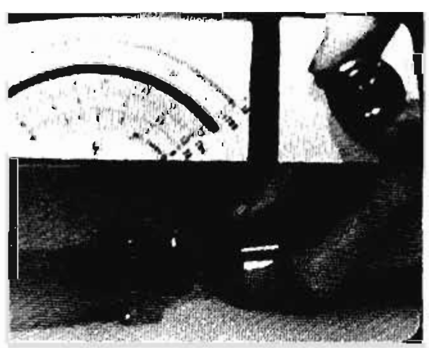
Logical Troubleshooting
Troubleshooting Transistor Circuits Faster

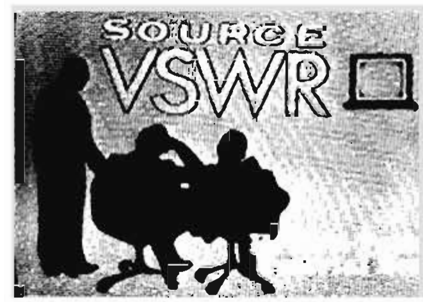
How to Use HP Instruments

5630A Computing Counter
Fourier Analyzer Applications
141T/8552B/8553B Spectrum Analyzer

How to Maintain HP Instruments

1700 Series Oscilloscope Service 2: Power Supply and Trigger Circuits
8064A Spectrum Analyzer Service (board level)
5061A Cesium Beam Tube Replacement
3590A/3591A Wave Analyzer Maintenance





Video Cassettes offer the ultimate in convenience and handling ease. Programs are available in this form as well as reel-to-reel.

For more information on

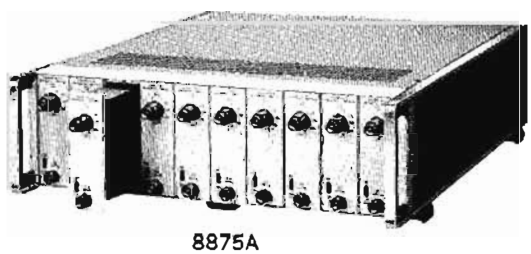
- Tapes
- Formats (½-in., 1-in., cassette)
- Equipment (playback/recorders, cameras, monitors)
- Prices (averaging $100/tape)

Contact your local Hewlett-Packard field representative or:

Corporate Training
Hewlett-Packard
640 Page Mill Road
Palo Alto, California 94304
(415) 493-1212

Professionally produced videotapes are developed to meet measurable instructional objectives in a wide variety of subjects. Note split-screen effect, above.

DIFFERENTIAL AMPLIFIER
Wideband amplifier for data acquisition systems
Model 8875A



8875A

The Model 8875A is a differential dc amplifier that provides high gain (up to 3000) and wide bandwidth. It features low drift for reliable, long term measurements, a common mode rejection of at least 120 dB at 60 Hz (500 ohm source unbalance, gain of 1000) and a common mode tolerance of ±20 V. Intermodulation distortion is avoided by use of direct-coupled input circuits (no choppers or modulators are used). An output having a capability of ±10 V at ±100 mA is standard, with a second independent output of ±10 V at ±10 mA optional. The 8875A is available as a single unit, in banks of up to 10 channels for rack mounting or in portable cases.

The 8875A is ideal for use with thermocouples, dc excited strain gages and other low level sources, with read out to devices such as digital voltmeters, oscillographs, analog-digital converters and similar units. Applications include space vehicle checkout, monitoring of physical variables, wind tunnel tests and arrangements with either input or output multiplexers.

Performance Specifications

Bandwidth: dc to 75 Hz within 3 dB, at fixed gain steps. Can be narrowed to as low as dc to 2 Hz with optional switch-selectable filter.

Gain: fixed steps of 1, 3, 10, 30, 100, 300, 1000 plus OFF; on any range, variable gain potentiometer may be switched to provide uncalibrated gain up to 3X gain switch setting. Gain accuracy ±0.1%; gain vernier allows setting any one fixed gain to an accuracy of 0.01%.

Input circuit: differential, active guarded; will accept floating input without ground return; may be used single-ended.

Input impedance: differential, 20 MΩ (±5%) with less than 0.001 μF shunt; common mode (guarded), greater than 2000 MΩ with less than 2 pF shunt.

Common mode rejection: at least 120 dB from dc to 60 Hz for up to 500Ω source impedance either side of input at gain of 1000; 66 dB minimum at gain of 1.

Common mode tolerance: ±20 V.

Input overload tolerance: ±30 V differential; ±70 V common mode will not damage the amplifier.

Output circuit: ±10 V across 100Ω (100 mA), output impedance (dc) 0.2Ω max. Short circuit proof; current limited to approx 150 mA. Will not oscillate with any value of capacity load.

Zero drift: ±3 μV referred to input, ±0.2 mV referred to output, at constant ambient temperature for 30 days. ±1 μV/°C referred to input, ±0.2 mV/°C referred to output. ±2 mV referred to output for ±10% change in line voltage.

Gain stability: ±0.01% at constant ambient temperature for 30 days, ±0.005%/°C (fixed gain steps only). ±0.01% for ±10% change in line voltage.

Nonlinearity: less than 0.01% of full scale 10 V output (zero based terminal linearity).

Current feed to source: 0.001 μA max at constant ambient temperature; ±0.001 μA/°C.

Settling time: 100 μs to 99.9% of final value for step input.

Overload recovery time: from differential overload signal of ±10 V at gains of 300 to 1000, recovery in 10 ms to within 10 μV, referred to input plus 10 mV referred to output: for gains of 1 to 100, recovery in 1 ms. For a 10X full scale overload of any duration, recovery in 2 ms for gains of 300 to 100, and 100 μs for gains of 1 to 100.

Noise: measured at gain of 1000 with respect to input, 1000Ω source impedance:

Bandwidth	Noise	Bandwidth	Noise
dc-10 Hz	1 μV pp	dc-10 kHz	3 μV rms
dc-100 Hz	3 μV pp	dc-50 kHz	4 μV rms
dc-1 kHz	6 μV pp	dc-250 kHz	5 μV rms

Slewing: gain of 1 or 3, 0.7 μV/s; gain greater than 3, 1 μV/s referred to output, for 10 mV dc offset at output with resistive load of 100Ω or greater.

Input-output isolation: greater than 200 MΩ shunted by less than 2 pF.

Temperature range: 0°C to 55°C.

General Specifications

Power: 115/230 V ±10%. 50 to 400 Hz, 6 VA.

Dimensions: 4¾" high, 1-9/16" wide, 15" deep (121 x 40 x 381 mm).

Weight: 3.5 lb (1,6 kg).

Prices: 8875A Differential Amplifier, $590.

Option 001: dual outputs (10 mA and 100 mA capability; short on one has negligible effect on other), add $75.

Option 002: switch selected filters (single-pole, low pass, with corner frequencies of 2, 200, 2000 and 20,000 Hz), add $75.

Option 003: gain ranges of 10, 20, 50, 100, 200, 500 and 1000, add $25

Option 004: 14010A Cord Connector Set for bench-top use (required for single-channel operation), add $65.

Option 005: combines Option 001 and 002 (filters on 10 mA output only), add $150.

Option 006: combines Option 002 and 003, add $100.

Note: must order 1069-01A case for multichannel banks of 10 or less. Sufficient blank panels (01069-61069) to fill case are required to maintain temperature stability specifications, $10 each.

SOLID-STATE AMPLIFIERS
Precision general-purpose amplifiers
Models 465A, 467A

465A

HP 465A Amplifier

Accurate gain, low noise and distortion, stability and versatility are offered at a low price by the Hewlett-Packard Model 465A. Switchable 20 dB or 40 dB gain (X10 or X100) with flat frequency response from 5 Hz to 1 MHz makes this amplifier a valuable tool in laboratories, production, maintenance, etc.

The 465A has numerous applications as a general-purpose amplifier or preamplifier, as an amplifier component in systems, and also as an impedance converter (10 MΩ to 50 Ω). The instrument can be isolated from chassis ground by disconnecting the ground strap on the front panel, which allows it to be floated up to 500 V dc above chassis ground.

465A Specifications

Voltage gain: 20 dB (X10) or 40 dB (X100), open circuit.

Gain accuracy: ±0.1 dB (±1%) at 1000 Hz.

Frequency response: ±0.1 dB, 100 Hz to 50 kHz; <2 dB down at 5 Hz and 1 MHz.

Output: >10 V rms open circuit; >5 V rms into 50Ω (0.5 W).

Distortion: <1%, 10 Hz to 100 kHz; <2%, 5 Hz to 10 Hz and 100 kHz to 1 MHz.

Input impedance: 10 MΩ shunted by <20 pF.

Output impedance: 50Ω.

Noise: <25 μV rms referred to input (with 1 MΩ source resistance).

Temperature range: 0°C to +50°C.

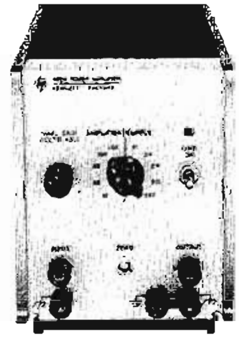
Power: 115 or 230 V ±10%, 48 to 440 Hz, 10 VA max.

Dimensions: 5⅛″ wide, 3″ high (without removable feet), 11″ deep (130 x 76 x 279 mm).

Weight: net, 4 lbs (1,8 kg); shipping, 7 lbs (3,2 kg).

Price: HP 465A, $260.

HP 467A Amplifier/Power Supply



467A

The solid-state HP 467A Power Amplifier/Supply is a 10-watt peak power amplifier and −20 to +20 volt dc power supply. The power amplifier has a wide bandwidth and low dc drift, suitable for many applications wherever a power source is required. Unique features are low distortion (<0.01%), low drift and high-gain accuracy.

An output greater than ±20 volts peak and ±0.5 A peak is available from dc up to 1 MHz. At full output the distortion of the 467A is less than 3% up to 1 MHz. The amplifier is a three-terminal device isolated from chassis and may be floated up to 200 volts dc above chassis ground.

467A Specifications

Power amplifier

Voltage gain (non-inverting): fixed steps: X1, X2, X5, X10.

Variable: 0-10 resolution is better than 0.1% of full output.

Accuracy: ±0.3% from dc to 10 kHz; ±1.0% from 10 kHz to 100 kHz; ±10% from 100 kHz to 1 MHz with load of >40Ω.

Output: ±20 V p at 0.5 A p.

Distortion: <0.01% at 1 kHz; <1% at 100 kHz; <3% at 1 MHz.

Input impedance: 50 kΩ shunted by 100 pF.

DC power supply

Voltage range: >±20 V, ±10 V, ±4 V, ±2 V, ±1 V; with adjustable vernier. Resolution: better than 0.1% of full output.

Current: ±0.5 A p.

Load regulation: (front panel) <10 mV, no load to full load.

Line regulation: <10 mV for a ±10% change in line voltage.

General

Output Impedance: (front panel): 5 mΩ in series with 1 μH.

Capacitance load: 0.01 μF or less does not cause instability.

Ripple and noise: <5 mV p-p (referred to output) for amplifier and power supply.

Current limit: <800 mA.

Temperature coefficient: <±0.05%/°C of output or ±2 mV/°C at output, whichever is greater.

Input-output terminals: front panel: ¾″ spaced banana terminals for input, output, and chassis. Rear panel: BNC terminals. Circuit ground can be floated 200 V dc above chassis ground.

Operating temperature range: 0°C to +50°C.

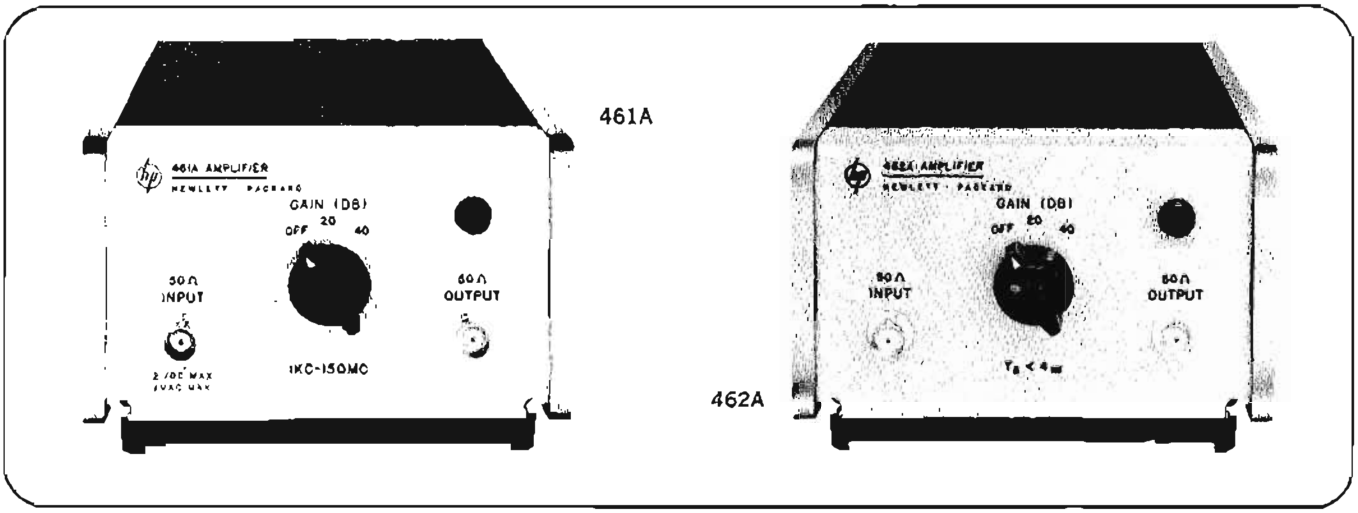
Power required: 115 or 230 V ±10%, 48 to 440 Hz; 60 VA max.

Dimensions: 5⅛″ wide, 6¼″ high (without removable feet), 11″ deep (130 x 159 x 279 mm).

Weight: net, 10 lbs (4,5 kg); shipping, 15 lbs (6,8 kg).

Price: HP 467A, $640.

SOLID STATE AMPLIFIERS
Wide-band, 40 dB general purpose amplifiers
Models 461A, 462A



Description

Uses

Loop-gain measurements.

Measurement of wide-band noise and VHF signals.

Preamplifier for voltmeters, oscilloscopes and counters.

Pulse preamplifier.

Linear amplifier.

Wide-band video amplifier.

General laboratory preamplifier.

The solid-state HP 461A and 462A Amplifiers are excellent wherever wide frequency range, low distortion, and portability are desired.

The 461A Amplifier is a general purpose instrument designed to deliver stable gain over a wide frequency range. Either 20 dB or 40 dB gain may be selected with a front-panel switch. Both input and output impedances are matched to 50 ohms. Maximum output is one-half volt rms.

The ability of the 462A to amplify very fast pulses can be seen in Figure 1. The upper trace (A) shows a 20 ns pulse applied to the input of the 462A Amplifier. The lower trace shows the same pulse amplified at 40 dB viewed on the Hewlett-Packard Sampling Oscilloscope.

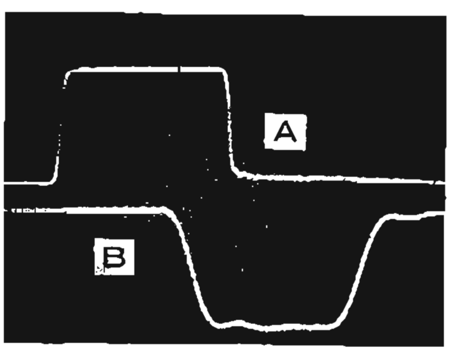


Figure 1. (A) Input Pulse to HP 462A (5 mV peak to peak). (B) Output Pulse of HP 462A (500 mV peak-to-peak). Gain control is set in 40 dB position. Sweep speed is 5 ns/cm. This amplifier gives maximum usefulness for fast-pulse applications, television, and vhf work.

Specifications, Model 461A

Frequency range: 1 kHz to 150 MHz.

Frequency response: ±1 dB, 1 kHz to 150 MHz when operating into a 50Ω resistive load (500 kHz reference).

Gain at 500 kHz: 40 dB ±0.5 dB or 20 dB ±1.0 dB, selected by front-panel switch (inverting).

Input impedance: nominal 50Ω.

Maximum input: 1 V rms or 2 V p-p pulse.

Maximum dc input: ±2 V.*

Maximum output: 0.5 V rms into 50Ω resistive load.

Equivalent wide-band input noise level: <40 μV in 40 dB position when loaded with 50Ω.

Distortion: <5% at maximum output and rated load.

Overload recovery: <1 μs for 10 times overload.

Specifications, Model 462A

Pulse response: leading edge and trailing edge: rise time, <4 ns; overshoot, <5%.

Pulse overload recovery: <1 μs for 10 times overload.

Pulse duration for 10% droop: 30 μs.

Pulse delay: nominally 12 to 14 ns.

Equivalent input noise level: <40 μV in 40 dB position (50Ω load).

Input impedance: nominal 50Ω.

Maximum input: 1 V rms or 2 V p-p pulse.

Maximum dc input: ±2 V.*

Gain: 20 or 40 dB selected by front-panel switch (inverting).

Output: 1 V p-p into 50Ω resistive load.

General specifications

Dimensions: 5⅛" wide, 3" high (without removable feet), 11" deep (130 x 76 x 279 mm).

Weight: net, 4 lbs (1,8 kg); shipping, 6 lbs (2,7 kg).

Power: 115 or 230 V ±10%, 50 to 400 Hz, 5 W.

Connectors: BNC female.

Accessories available: 11048C, 50Ω Feed-thru Termination, $15; Combining Cases: 1051A (holds six HP 461A Amplifiers), $135.

Price: HP 461A, $380; HP 462A, $380.

*For the protection of the input circuitry.

DATA AMPLIFIER

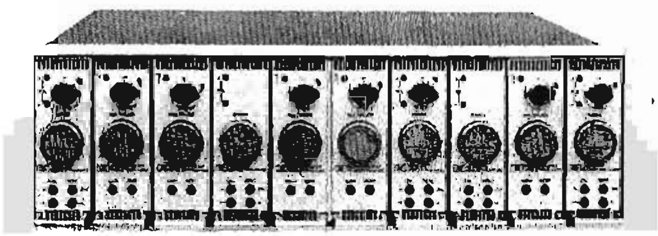
DC — 50 kHz differential amplifier

Model 2470B & Option 003

Description

The HP 2470B Amplifier is a wideband differential amplifier. Its high common mode noise rejection (120 dB) and low zero drift make the 2470B particularly well suited to all types of signal conditioning applications. Typical inputs to the 2470B include strain gauge bridge transducers, thermocouples, potentiometer pick-ups, and resistance transducers. Excellent gain stability, both long and short term, avoids the need for frequent gain adjustment . . . real convenience in multiple amplifier systems . . . and also allows the 2470B to be used for monitoring drift of dc signal sources in conjunction with a strip chart recorder.

The amplifier with its power supply is packaged compactly. Ten instruments fit side-by-side in 5¼" of standard 19" rack space, or two instruments may be installed in a portable case.



2470B
Combining Case

2470B

2470B
Option 003

Specifications

Specifications include ±10% line voltage variation, hold for 1 kΩ max. source resistance, (any unbalance) and assume calibration after specified warmup. (rti and rto mean referred to input and referred to output.)

DC gain: 6 fixed steps of X1, X10, X30, X100, X300, X1000. Vernier (Opt 003) selected at front panel 10-turn potentiometer (front panel) extends gain up to X3.5, for any gain setting.

DC gain accuracy: calibrated gain: .01% of output; other gains: .03%, consisting of .02% gain-to-gain accuracy and .01% gain trim resolution. Vernier (Opt 003) Dial Accuracy: ±3% of output. Resolution: ±.05% of full scale. Resettability: ±.08% of full scale.

Gain stability: dc: ±.005% of output per month; ac: ±.1% per month, for ac to 2 kHz; temp. coeff: ±.001% per °C. (±0.002%/°C in Opt 003.)

Linearity: dc: ±.002% of full scale, referred to straight line through zero and full scale output; ac: ±.01% of full scale; inputs to 2 kHz.

Zero drift (offset): per day: ±5 μV rti (referred to input) 200 μV rto (referred to output); per month: ±24 μV rti ±500 μV rto; temp coeff: ±1 μV ±.5 namp rti ±40 μV rto per °C. (Opt 003 increases rto offset by a factor of up to 2.5).

Maximum input signal: ±11 V referred to input.

Differential input impedance: 10^9 ohms shunted by .001 μF.

Common mode rejection: 120 dB at 60 Hz for gains of X30 and higher.

Common mode return: from input common to output common; 1 megohm, max.

Noise: 0 to 10 Hz: 1μ V p-p rti and 10 μV p-p rto; 0 to 50 kHz: 5 μV rms rti and 500 μV rms rto.

Output: ±10 V max, 0 to 100 mA. Self-limits.

Output impedance: 0.1 ohm in series with 10 μH max.

Load capability: 100 ohms or .01 μF for full output.

Slewing: 10^6 V/s at gain of 1; 5 x 10^6 V/s at gain of 1000.

Bandwidth: for any gain step, 0 to 50 kHz ±3 dB; 0 to 15 kHz ±1 dB; 0 to 5 kHz ±1%; 0 to 1.5 kHz ±.1%; 0 to 500 Hz ±.01%.

Settling time: 100 μs to within .01% of final value.

Overload recovery: 200 μs to within .01% of final value for signal of 10 times full scale, but less than 10 V; less than 5 ms for signal plus common mode up to 20 V.

Overload signal: −17.5 to −19.5 V with no overload, 0 to −1 V in overload; 5 mA drive capability; front panel lamp indication.

Operating conditions: ambient temperatures 0 to 55°C; relative humidity to 95% at 40°C.

Warmup: operates immediately after turn-on, but requires three hours in free air, 30 minutes to Portable Case or Combining Case (plus one hour additional warmup for each 10°C difference between storage temperature and operating ambient) for specified accuracy and zero drift.

Reliability: predicted MTBF (90% confidence) 20,000 hours when operated at 25°C ambient.

Power: 115 or 230 V ±10%, 48 to 440 Hz, 10 VA max.

Dimensions: 1-9/16" wide, 4⅞" high, 15" deep (39.7 x 123.9 x 381 mm).

Weight: net, 4 lbs (1,8 kg); shipping, 6½ lbs (2,9 kg).

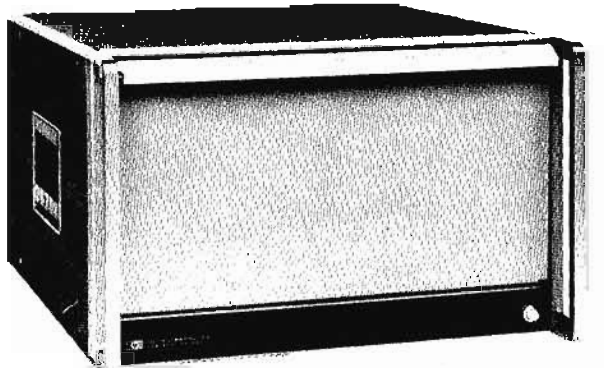
Accessories available: mating rear connector; mating rear connector with power cord, input/output cables; combining case: holds up to 10 instruments in 5¼" of standard 19" rack space (mating connectors furnished) includes power cord and fan; portable case: holds two amplifiers (mating connectors furnished) and includes power switch, pilot light, power cord and fan.

Price: HP 2470B, $725; Option 003 with vernier, add $100.

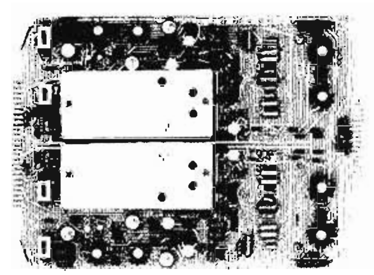
SYSTEM DATA AMPLIFIER

Excellent performance at lower cost

Model 2471A



12670A Combining Case



2471A System Data Amplifier

The HP 2471A System Data Amplifier is a wideband differential-input amplifier featuring excellent system performance at low per-channel cost through extensive use of integrated circuits and modern plug-in-design packaging techniques.

The 2471A is a single plug-in circuit board which consists of two identical and independent amplifier channels, each providing up to ±10 V, 50 mA full-scale output. Each channel has four switch-selectable calibrated gains from 1 to 1000 in decade multiple steps. Bandwidths are also selectable for each channel by plug-in jumpers with a choice of 10 Hz, 100 Hz, 1 kHz, and 10 kHz controlled bandwidths with 12 dB-per-octave rolloff, and full bandwidth (greater than 50 kHz). Common mode rejection is >80 dB at the two lowest gains and >120 dB at the highest gain

Up to 10 amplifier boards (20 channels) may be installed in a model 12670A Combining Case which includes power supplies and connectors for all boards. The case occupies only 10½ inches of rack space. A pull-down front panel allows direct access to the boards. The amplifier boards are furnished with mating connectors, simplifying installation where the combining case is not used.

The system data amplifier is ideally suited for amplification of strain gage bridge, thermocouple and other low-impedance sources. The amplifier output is compatible with high-speed analog-to-digital converters such as used in computerized data acquisition systems.

Specifications, 2471A*

DC gain: selectable in 4 fixed steps of x1, x10, x100, x1000.

DC gain accuracy: ±0.01%.

DC gain stability: ±0.02% of output for 6 months; temp. coeff. ±.005% per °C.

DC linearity: ±0.01% of full scale, referred to straight line through zero and ± full scale output.

Zero drift: per day: ±10 μV rti ±1 mV rto. Voltage temp. coeff.: ±1 μV rti ±0.2 mV rto per °C. Current temp. coeff.: ±0.5 nA rti per °C.

Maximum input signal: ±11 V differential plus common mode; combined input of ±20 V will not damage the amplifier.

Common mode rejection (CMR): dc to 60 Hz, up to 1 KΩ line unbalance:

Gain	*CMR*
1000	>120 dB
100	>100 dB
10,1	> 80 dB

Common mode return: from input common to output common: 10 megohms max.

Noise:

(with source resistance <1 kΩ)	*Bandwidth*	*Noise*
	0 - 10 Hz	3 μV peak-to-peak
	0 - 50 kHz	<5 μV rms rti, <0.5 mV rms rto

Output: ±10 V max. 0 to 50 mA. Short-circuit proof.

Output Impedance: <0.1 ohm in series with 10 μH.

Load capability: 200 ohms resistive. Capacitive load up to 0.01 μF will not cause instability.

Slewing rate: >1 V per μsec.

Bandwidth: selectable in 5 steps: 10 Hz, 100 Hz, 1 kHz, 10 kHz with 12 dB-per-octave rolloff and max. amplifier bandwidth of >50 kHz.

Operating conditions: ambient temperature 0 to 55°C; relative humidity to 95% at 40°C.

Power required: +30 V @ 50 mA, −30 V @ 50 mA, +15 V @ 60 mA plus 50 mA max. load current, −15 V @ 60 mA plus 50 mA max. load current.

Power supply immunity: ±30 V, >120 dB rti; ±15 V, >40 dB rto.

Dimensions: 7¾" H (197 mm), 1¼" W (31,8 mm), 10⅝" D (269 mm).

Weight: net 1¼ lb (567 gm); shipping 2 lb (0,91 kg).

HP 12670A Combining Case: (includes integral power supply and holds up to ten 2471A Amplifiers (20 channels).

Power: 115 or 230 V ±10%, 50-400 Hz, 110 watts (for full complement of 20 channels).

Dimensions: 10½" H (267 mm), 19" W (483 mm), 20⅝" D (508 mm).

* rti: referred to input; rto: referred to output.

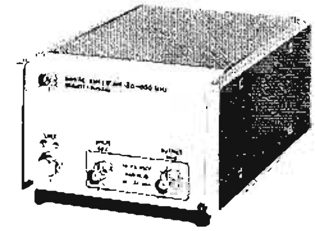
WIDE BAND AMPLIFIERS

Low noise, flat response

Models 8447A, 8447B, 8447C, 8447D, 8447E, 8447F

Thin film hybrid integrated circuit amplifiers have been combined with fully regulated, solid state power supplies to form a series of general purpose amplifiers. The HP 8447 series of amplifiers embodies the inherently high reliability of integrated circuits and the convenience of a small, lightweight package.

The series features low noise and wide bandwidth. Flat frequency response and low distortion enhance the general utility of the amplifiers. Long term stability and reliability is assured by the use of microelectronic amplifier circuits.



8447C

Specifications

	8447A Preamp	8447B Preamp	8447C Power Amp	8447D Preamp	8447E Power Amp	8447F Preamp-Power Amp
Frequency Range	0.1 - 400 MHz	0.4 - 1.3 GHz	30 - 300 MHz	100 kHz - 1.3 GHz	100 kHz 1.3 GHz	100 kHz - 1.3 GHz
Typical 3 dB Bandwidth	50 kHz - 700 MHz	0.35 - 1.35 GHz	10 - 400 MHz	50 kHz - 1.4 GHz	50 kHz - 1.4 GHz	50 kHz - 1.4 GHz
Mean Gain	20 dB ±0.5 dB at 10 MHz	>20 dB 22 dB Typical	30 dB ±1 dB	26 dB ±1.5 dB (20° – 30°C)	22 dB ±1.5 dB (20° – 30°C)	8447D AND 8447E COMBINED IN A SINGLE PACKAGE
Gain Flatness across full Frequency Range	±0.5 dB	±1.5 dB	±1 dB	±1.5 dB	±1.5 dB	
Noise Figure	<5 dB	<5 dB 0.4 - 1.0 GHz <6 dB 1.0 - 1.3 GHz	<11 dB	<8.5 dB	<11 dB Typical	
Output Power for 1 dB Gain Compression	> +7 dBm	> −3 dBm	> +17 dBm	> +7 dBm Typical	> +15 dBm	
Harmonic Distortion	−35 dB for 0 dBm output	−30 dB for −15 dBm output	−35 dB for +10 dBm output	−30 dB for 0 dBm output (typical)	−30 dB for +10 dBm output	
Typical Ouput for < −60 dB Harmonic Distortion	−25 dBm	−45 dBm	−15 dBm	−30 dBm	−20 dBm	
VSWR	<1.7	<2.0 Input <2.2 Output	<2.0	<2.0 Input <2.2 Output 1 - 1300 MHz	<2.2 1 - 1300 MHz	
Impedance	50Ω	50Ω	50Ω Opt 002 75Ω	50Ω	50Ω	
Reverse Isolation	>30 dB	>40 dB	>35 dB	>40 dB	>40 dB	
Maximum DC Voltage Input	±10 V	±10 V	±10 V	±10 V	±10 V	

General

Power requirements: 110 or 230 V ac ±10%, 48-400 Hz 15 watts.

Dimensions: 8½″ (216 mm) deep by 5⅛″ (130 mm) wide by 3⅜″ (85,8 mm) high.

Weight: net, 3 lb, 7 oz (1,56 kg); shipping, 5 lb, 1 oz (2,30 kg).

Price: Model 8447A, $550; Model 8447B, $600; Model 8447C, $450; Model 8447D, $650; Model 8447E, $700; Model 8447F, $1175.

Options Available

	Option 001 Dual Channel BNC Connectors	Option 010 Type N Connectors	Option 011 Dual Channel Type N Connectors	Option 002 75Ω Input and Output Impedance
8447A	* $400	–	–	–
8447B	* $450	* $50	* $500	–
8447C	–	–	–	* $10
8447D	* $500	* $25	* $550	–
8447E	–	* $25	–	–
8447F	–	* $50	–	–

*This option available on Model shown. Order by Model number, then Option, e.g., 8447A Opt 001. Option price is extra.

MICROWAVE/POWER AMPLIFIERS
Broadband, high-gain, high power amplification
Model 489A, 491C, 493A, 495A, 230B

Microwave TWT amplifiers

489A

Advantages:

DC-coupled modulation circuitry allows power leveling and remote programming

Periodic-permanent-magnet focusing means fewer alignment problems

Uses:

Antenna efficiency and pattern measurements

Extends attenuation measuring systems capability by at least 30 dB.

Amplification of frequencies from 1 to 12.4 GHz is accomplished in four ranges by the Hewlett-Packard microwave amplifiers. Each delivers over 1 watt with an input of 1 mW or less, a gain of at least 30 dB.

Specifications

Input/output: impedance, 50Ω; connectors, type N female.

Amplitude modulation:

Sensitivity: modulation input of >-20 V peak reduces RF output by more than 20 dB from dc to 50 kHz.

Frequency response: dc to 500 kHz (3 dB).

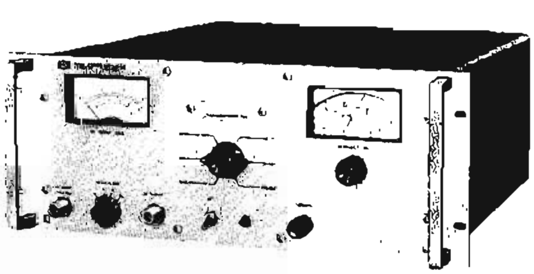
Pulse response: <1 μs rise and fall times.

Dimensions: 16¾" wide, 5½" high, 18⅜" deep (426 x 140 x 467 mm).

Weight: net, 33 lbs (14,9 kg); shipping 40 lbs (18,0 kg).

	489A	491C	493A	495A
Frequency range (GHz)	1-2	2-4	4-8	7-12.4
Power output (with 1 mW or less input)	1 W	1 W	1 W	1 W
Gain at rated output	30 dB	30 dB	30 dB	30 dB
Gain variation with freq. at rated output	≤6 dB	≤6 dB	≤6 dB	≤6 dB
small signal across any 10% of band	≤5 dB	≤5 dB	≤5 dB	≤5 dB (for 300 MHz)
across full band	≤12 dB	≤12 dB	≤12 dB	≤10 dB
Noise max. noise figure	30 dB	30 dB	30 dB	30 dB
Price	$2450	$2450	$2800	$2800

230B Tuned RF power amplifier



230B

The HP 230B is a tuned RF power amplifier covering 10 to 500 MHz in six continuous ranges. It provides up to 30 dB of gain, and has a maximum rated power output of 4.5 watts. With a typical noise figure of 6 to 9 dB, it is also suitable for low-level applications. High and low-level applications of the power amplifier are discussed in Application Note 76.

Specifications, 230B

Frequency range: 10 to 500 MHz in six bands: 10 to 18.5 MHz, 18.5 to 35 MHz, 35 to 65 MHz, 65 to 125 MHz, 125 to 250 MHz, 250 to 500 MHz.

RF gain: 30 dB (10 to 125 MHz), 27 dB (125 to 250 MHz), 24 dB (250 to 500 MHz), with 10 volts output into 50 ohms.

RF bandwidth: >700 kHz (10 to 150 MHz), >1.4 MHz (150 to 500 MHz), with 10 volts output into 50 ohms.

RF output:

Level: up to 15 volts across external 50-ohm load (4.5 watts).

Level monitor: full scale ranges of 3, 10, and 30 volts, accurate to 10% from 10 to 500 MHz.

AM range: reproduces 0 to 100% modulation of driving source.

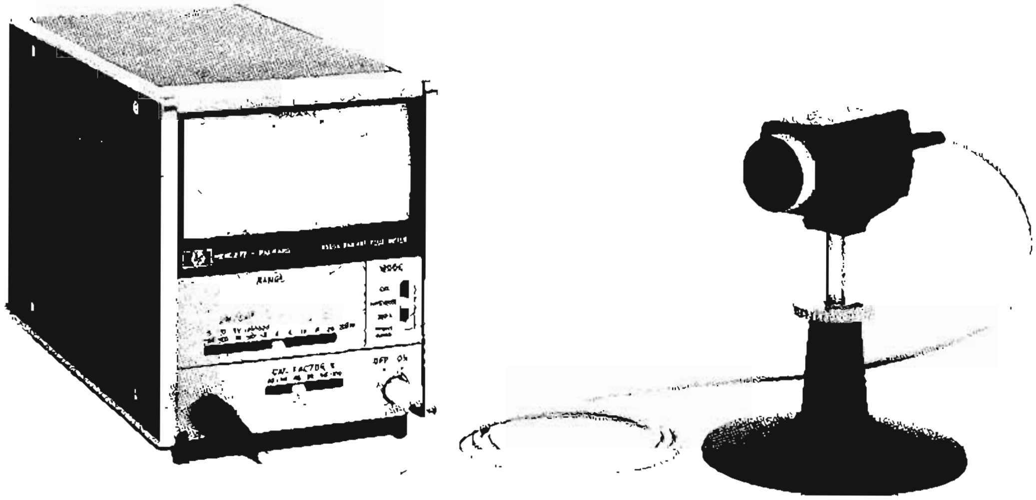
Connectors: type N female.

Dimensions: 16 3/4" wide, 7 3/16" high, 18 1/16" deep (425 x 183 x 459 mm).

Weight: net, 35 lbs (15,8 kg); shipping 52 lbs (23,4 kg).

Price: $1190.

RADIANT FLUX METER AND DETECTOR
Measure UV, visible and infrared radiation
Model 8330A, 8334A



8330A 8334A

Description

The Model 8330A Radiant Flux Meter and Model 8334A Radiant Flux Detector combine to form a complete, multipurpose optical radiometer system ideally suited for use in a wide variety of exacting applications involving the accurate measurement of radiant power density in the ultraviolet, visible and infrared regions of the electromagnetic spectrum.

Direct readout in absolute units

The complete system is fully calibrated and reads directly in absolute radiometric units of watts per cm² at any wavelength and at any power level within the range of the detector. The uniform, flat spectral response of the detector eliminates the need for inconvenient spectral calibration curves, thus enabling the convenient measurement of monochromatic radiation as well as the accurate measurement of spectrally-distributed (non-monochromatic) radiation from optical sources such as thermal blackbody radiators.

Thin-film Thermopile Detector

Key to the exceptionally high performance of the complete system is the unique, Hewlett-Packard-designed and manufactured thin-film thermopile detector. This multijunction thermocouple-type detector exhibits a combination of flat spectral response, fast rise time and mechanical ruggedness not found in conventional designs.

Convenient to use

The instrument is particularly convenient and easy to use compared with previously available optical radiometers. The front panel meter can be automatically zeroed by simply depressing the front-panel MODE switch. No manual zero knob adjustment is needed. A pushbutton-operated, built-in electrical substitution-type calibrator keeps the fully integrated system operating at maximum accuracy at all times.

Applications

The 8330A/8334A system is useful in a wide range of laboratory, industrial and field applications in a number of different areas such as optical science and engineering, process control, biological science and many others.

Specifications, 8330A/8334A

Dynamic range: irradiance measured in 10 overlapping (1:3:10 sequence) ranges from 3 μW/cm² to 100 mW/cm² full scale.

Accuracy: absolute measurement uncertainty of broadband irradiance is less than ±5% of full scale on any range.

Spectral range and flatness: standard version of Model 8334A is equipped with Infrasil quartz optical window and responds from at least 0.3 to more than 3.0 microns, flat to within ±3% or less (measured with grating monochromator with better than 0.1 micron resolution). Spectral range is extendable beyond these limits using specified alternate optical window materials. Windows are not interchangeable.

Response time, 10-90%: measured at recorder/DVM output is: <70 msec on 3, 10, 30, 100 mW/cm² ranges: <0.7 sec on 100, 300 μW/cm² and 1 mW/cm² ranges, <2.7 sec on 3, 10, 30 μW/cm² ranges.

Zero drift: typically less than 3.0 μW/cm²/hr in laboratory environment with reasonably constant ambient temperature.

Recorder/DVM output: 0-1 volt dc. BNC connector.

Power requirements: 115/230 V ac ±10%, 50-400 Hz, 2.5 watts.

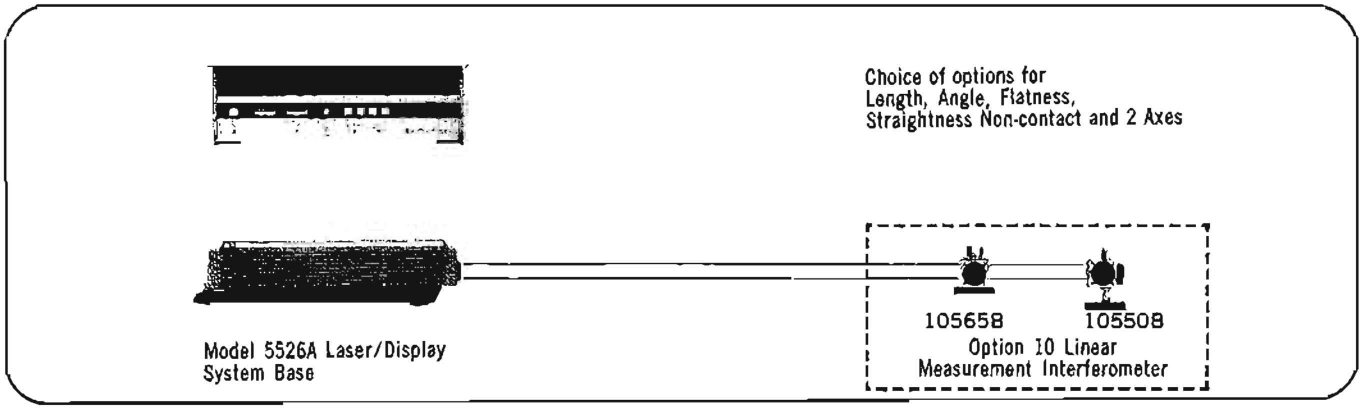
Weight: 8330A: net, 6 lbs 15 oz (3,2 kg); shipping, 9 lbs 14 oz (4,6 kg). 8334A: net, 1 lb 5 oz (0,8 kg); shipping, 1 lb 15 oz (1 kg).

Dimensions: (approximate), 8330A: 6½" high, 5⅛" wide, 11½" deep (165 x 130 x 285 mm) 8334A: (including stand) 6¼" high, 4¾" wide, 5" long (160 x 121 x 127 mm).

Accessories furnished: 7½' (2,3 m) power cable. Adjustable height stand and ⅜" diameter support rod (pin mount) for detector.

Price: Model 8330A, $850. Model 8334A with Infrasil quartz window, $550; detectors with alternate types of optical windows can be supplied on special order at extra cost.

LASER INTERFEROMETER
Linear & Angular Measurement
Models 5526A, 5510A



Configuration

The Laser Measurement System is a major advance in economical dimensional metrology. With a multi-purpose two channel laser head, interferometer options are available to measure length, angle, flatness, straightness and squareness and two measurements simultaneously. The 5526A, which forms the base of the system, includes the 5500C Laser Head and the 5505A Laser Display.

General capabilities

The system is a highly accurate displacement measuring tool with a resolution of one millionth of an inch (linear) and 0.1 arc-second (angular). Fully automatic tuning, instant warm-up, and remote interferometry assure drift-free accuracy from the instant of switch-on. A laser tube lifetime in excess of 10,000 hours can confidently be expected. The unique optical heterodyning principle makes for practical, convenient measurements in adverse environments.

There is no interferometer in the laser head so all users benefit from the advantages of remote interferometry at no extra cost. Price: 5526A Laser/Display: $9,100.

Interferometer options

Option 010—Linear Interferometer

This consists of the 10565B Remote Interferometer (Magic Cube) and a 10550B Retroreflector. Since the Remote Interferometer is completely passive it makes for an almost perfect linear measuring instrument. Although it may be placed in the laser head, it offers significant advantages when used remotely. Complete thermal stability is assured since the laser head can be some distance away on a tripod, while its small size makes for easy fixturing and minimal distortion. Deadpath can be virtually eliminated and, due to its small size, permanent installation in machines is very attractive. Price: $3,300.

Option 020—Linear + Angular/Flatness Interferometer

The addition of two simple optical modules to the Magic Cube converts it into an angular measuring interferometer for fast, accurate measurements of pitch, yaw, or flatness. The option also includes two turning mirrors designed especially for rapid calibration of surface plates. Price: 5,120.

Option 030—Straightness Interferometer

This option converts the 5526A into an interferometric straightedge. Lateral deviations from a perfectly straight line are displayed to a resolution of one millionth of an inch to an axial range of 10 feet or more. Unlike alignment lasers the Hewlett-Packard system does not depend on the pointing stability of the laser beam for its reference, but instead uses two rigidly mounted plane mirrors and a special prism interferometer. Accuracy is ±5 microinches/ft ±1 count.

Squareness: By passing the straightness interferometer beam through a 90° beam bender, Option 030 can be used to check squareness. Thus, the same instrument which calibrates a machine tool or measuring machine for coordinate positioning accuracy can also check geometry. Price: To be announced.

Option 040—Single Beam Interferometer

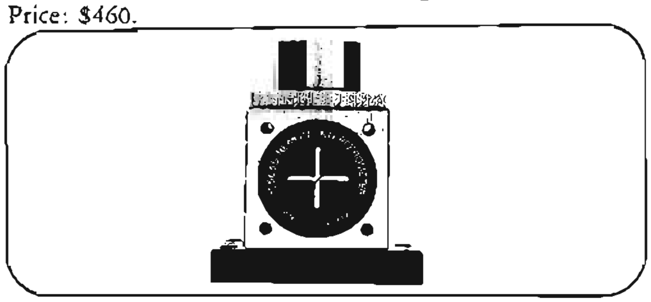
This is a special type of remote interferometer for use where a cube-corner would present serious disadvantages. With the K08-10565A Non-contact Converter it measures displacement of reflective surfaces. Price: $2,500.

Option 011—Second Axis Add-on

The laser head is equipped with two sets of photodetectors. By the addition of Option 011, two measurements may be made simultaneously. Price: $7,650.

Option 012—Plane Mirror Conversion Kit

This includes the 10581A Plane Mirror Converter which, when assembled onto the Remote Interferometer of Option 010, converts it into a plane mirror interferometer. This is a very useful method of measuring XY displacements. Since it is insensitive to tilt of the mirror, alignment is not critical. Price: $460.



Option 021—Angular/Flatness Add-on

Angular or flatness measurement may be added to Option 010 at any time with this option which includes a Beam Bender, Reflector Mount, two Turning Mirrors and a Storage Case. Price, $1,820.

Option 013—Second Axis Add-on (Plane Mirror)

For two-axis plane reflector measurements, this option should be ordered with Option 010, 011 and 012. It is very useful for XY table applications. Price: $8,110.

5510A—Automatic Compensator

The Automatic Compensator provides accurate, continuous correction for variations in the refractive index of air and for temperature of the material being measured. Air temperature, pressure and humidity and material temperature are measured by rugged sensors designed especially for use in machine shops. Sensor readings can be observed at the Laser Display without disturbing the measurement. Price: $3,750.

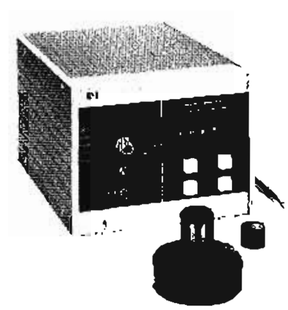
Other options

Additional options include real time error-plotting, fringe based pulse or quadrature signals for closed-loop control, and a real-time resolution extender for applications where 0.1 millionths of an inch (0.001 micrometers) is needed, or where the high update rate of the normal mode is needed with the resolution of the X10 mode. A printer is also available.

Brief specifications

5526A Laser/Display

Laser: Helium-Neon type. Fully automatic tuning. Instant warmup.
Accuracy: (for all linear displacement measurements):
- **Inch units:** ±0.5 parts per million ±1 count in last digit.
- **Metric units:** ±0.5 parts per million ±2 ounts in last digit.



5510A

Resolution: Normal and Smooth modes:
Normal 0.000,01 in. Metric: 0.1μ. Angular: 1 arc-sec.
X10 0.000,001 in. Metric: 0,01μ. Angular: 0.1 arc-sec.
Maximum allowable signal loss: 95% (−13 dB).
Maximum measuring velocity: 720 in/min (182 m/min).
Maximum lateral return beam offset: ±0.2 inch (±5 mm).
Atmospheric and material compensation: manual input from tables. 5510A Automatic Compensator optional.
Dimensions:
- **Display:** 5.53″ high x 16.75″ wide x 13.25″ deep (141 mm x 436 mm x 337 mm).
- **Head:** 5.00″ high x 7.00″ wide x 20.70″ long (127 mm x 178 mm x 526 mm).
- **Weight:** Laser Display: 24 lb (19,9 kg); Laser Head: 17 lb (7,8 kg).

Option 10—Linear Interferometer

Accuracy: as for 5526A Laser/Display.
Maximum measuring range: up to 700 feet (210 m) depending on conditions.
Maximum lateral offset: The remote interferometer or the cube-corner retroreflector may be offset by up to ±0.1 in. (±2.5 mm) since a cube-corner displacement is doubled for the reflected beam.
Dimensions: Too numerous to list. Ask for 5526A data sheet.
Weight: 10565B Remote Interferometer: 2.7 lb (1,1 kg); 10550B Reflector and Mount: 2.0 lb (0.8 kg).

Option 20 — Linear + Angular/Flatness Interferometer
Linear specifications are as for Option 10

Accuracy:
- ±0.1 arc-second (±1 count in last digit) up to ±100 arc-seconds.
- ±1 arc-seconds (±1 count in last digit) up to ±1000 arc-seconds.
- ±4 arc-seconds per degree (±1 count in last digit) up to 10 degrees using correction table.

Option 30—Straightness Interferometer

Accuracy:
- **Straightness Reference:**
  - **Inch:** ±5 microinches/foot ±1 count in last digit.
  - **Metric:** ±0.4 micrometer/meter ±2 counts in last digit.
- **Calibration:** ±3% of reading. Can be calibrated out with the gain adjustment of an analog recorder, if used.

Resolution: As for 5526A Laser/Display.
Lateral range: ±0.1 inch (±2.5 mm).
Axial range: 10 feet (3 m).

Option 012—Plane Mirror Interferometer (with Opt. 010)

Performance: As for the Model 5526A Laser/Display and Option 10 Linear Interferometer.
Reflector requirements:
- **Flatness:** Must not deviate by more than λ/8 (3 microinches) over any 0.8 inch (20 mm) dimension.
- **Surface Finish:** Metal 0.1-0.3 microinch arithmetic average Optical 80-40.
- **Maximum Angular Misalignment:** Depends on distance between interferometer and mirror plane. Typical values are:
  - ±25 arc-minutes for 10 in. (254 mm)
  - ±15 arc-minutes for 20 in. (508 mm)
  - ±5 arc-minutes for 50 in. (1270 mm)

Weight: Model 10581A 0.5 lb (225 gm).

5510A Automatic Compensator

Dimensions: 6.25 in. x 7.75 in. x 11 in. (159 mm x 197 mm x 280 mm) w/o sensors. With sensors depth increases by 3 in. (76 mm).
Weight: 10.8 lb (4.9 kg).

5501A Laser Transducer

This new product is a laser-based linear and angular transducer designed primarily for original equipment manufacturers of numerically-controlled machine tools, measuring machines, and other precision positioning equipment. Using a **single** remote laser source and miniaturized optical and electronic components, the modular system is able to monitor up to eight axes simultaneously. Since pitch and yaw can be measured, as well as position, the same transducer yields both positioning and corrective control feedback. The transducer requires no periodic recalibration. The 5501A Laser Transducer contains options to interface with most hard-wired and mini computer controllers. Price: To be announced.

Specifications

Resolution: 6 microinches (0.15 micrometers).

Accuracy: ½ parts per million.

Range: 200 feet (65 meters), sum of axes.

Maximum Allowable Velocity: 720 inches/minute (0.3 meters/sec).

Number of Axes: 1 to 8.

QUARTZ THERMOMETER
0.0001°C or °F resolution, direct measurement
Models 2801A, 2831A, 2833B, 2850A/B/C

Description

The method of temperature sensing employed in the 2801A Quartz Thermometers is based on the sensitivity of the resonant frequency of a quartz crystal to temperature change.

Temperature range of the 2801A Quartz Thermometer is −80 to +250°C (−112 to +482°F). The quartz thermometer is considerably more linear than a platinum resistance thermometer: ±.05% of span from −40 to +250°C compared with a typical figure of ±.55% for the same range for platinum thermometers. Linearity of the quartz thermometer is superior to that of thermocouples and thermistors, which have an exponential characteristic. The excellent sensing characteristics of the quartz thermometer are supplemented by the advantages of direct digital readout (no bridge balancing, or reference to resistance or voltage-temperature tables or curves), immunity to noise and cable resistance effects, no reference junction, and good interchangeability between sensing probes.

The 2801A is equipped with two sensing probes for measuring temperature at either probe or the difference between the two. A 6-digit visual readout and recording output with a choice of push-button-controlled sample times provides resolution of 0.01, 0.001 or 0.0001°C or F. With Option 010 (100 second sample period) resolutions of 0.001, 0.0001 or 0.00001°C or °F can be obtained. Signal polarity indication is provided. The 2801A includes the capability for operation as a 300 kHz electronic counter.

Temperature sensing probes

Various standard probe configurations are available for the 2801A Quartz Thermometer. Probes from the 2850 series are furnished with the quartz thermometer.

Remote operation of probes

Each temperature sensing probe has a quartz-crystal which is resonant at a frequency dependent upon temperature, and is driven by a 2830A Sensor Oscillator. The oscillators are transistorized devices enclosed in small die-cast aluminum housings. They are normally installed in the 2801A flush-mounted in a front panel recess. A 12-foot cable connects each probe to its associated sensor oscillator; this cable forms part of the tuned circuit and cannot be altered in length. However, the sensor oscillators may be unplugged from the instrument and connected to it by standard 75-ohm coaxial cable up to 500 feet in length, with no loss in measurement accuracy. For greater distances, one or two 2831A Amplifiers may be used for a maximum of 4500 feet.

Oceanographic temperature sensor

The Model 2833B Oceanographic Temperature Sensor Assembly for the 2801A Quartz Thermometer is especially designed for use in rugged environments such as oceans, rivers, harbors and industrial fluids at pressures up to 10,000 psi. It meets all requirements for oceanographic investigations, for temperature profile and thermal pollution studies in rivers and harbors, for well-logging, factory effluent studies and other difficult industrial environments.

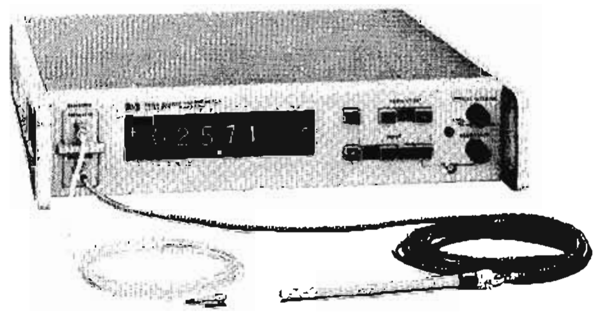
The 2833B combines the functions of a quartz crystal sensor and oscillator which are housed in a stainless steel pressure case approximately 5⅜ inch long, with a maximum diameter of ⅞ inch. A single coaxial cable transmits the temperature signal to, and the dc operating power from the 2801A.

The 2833B connects directly to the 2801A through the cable provided and gives a direct digital readout in °C or °F. Operating range of the 2833B is −40 to 120°C (−112 to +248°F) when used with the 2801A Quartz Thermometer. It may be used with as much as 5000 feet of cable with no loss of accuracy or sensitivity.

Specifications, 2801A

Temperature range: −80 to +250°C (−112 to +482°F with Option 001).

Calibration accuracy: thermometer-probe combination calibrated at factory to within .02°C (.04°F) absolute, traceable to NBS.



Linearity: −40 to +250°C: better than .15°C (.27°F) referred to best fit straight line through 0°C; −80 to −40°C: better than 0.7°C (1.25°F) referred to same line as above; 0 to +100°C: better than .05°C (.09°F) referred to best fit straight line through 0°C.

Stability

Short term: better than ±.0001°.

Long term: zero drift less than ±.01°C (.018°F) at constant probe temperature for 30 days.

Ambient temperature effect: less than .002°C per °C change.

Display: 2801A: 6-digit in-line readout in C°, or °F. Decimal point, °C (°F), and polarity indication included. Readout and units incation in kHz in counter mode of operation. Storage feature holds display between readings.

Digital recorder output: BCD, 4-2'-2-1, positive-true, for each digit, decimal point (exponent), polarity, and operating mode. 8-4-2-1 positive true optionally available.

External programming: selected by contact closures or transistor circuit closures to ground. Measurement initiation, probe selection (T1, T2, or T1—T2), and resolution (.01, .001, or .0001°) programmable.

Counter operation: Frequency Range: 2 Hz to 300 kHz; Resolution: 10, 1, and 0.1 Hz; Sensitivity: 0.5 to 10 V rms; Input Impedance: 1M, 50 pF shunt; Gate Time: 0.1, 1 and 10 sec.

Power required: 115/230 V ±10%, 50 to 60 Hz, 85 W.

Instrument environment: ambient temperatures from 0 to +55°C (+32 to +130°F), at relative humidity to 95% at 40°C.

Weight: net, 22.5 lbs (10,1 kg); shipping, 35 lbs (15,9 kg).

Dimensions: 3-15/32" x 16-5/16" x 16¾" (88 x 414 x 425 mm).

Price: 2801A Quartz Thermometer, including two 2830A Sensor Oscillators and two (matched) 2850 series Temperature Sensors, $3250.

Specifications, HP 2831A Amplifier

Operating frequency: 28 to 29 MHz approx.

Gain: 40 dB approx.

Power required: +12 to +20 V dc, at 8 mA approx. (Normally supplied by HP 2801A.)

Connectors: coaxial output connector mates with HP 2801A Quartz Thermometer.

Operating conditions: same as HP 2830A Sensor Oscillator.

Dimensions, weight, finish: same as HP 2830A Sensor Oscillator.

Price: 2831A Amplifier, $100.

Specifications 2833B Oceanographic Sensor

Temperature range: −40 to +120°C (−112 to +248°F).

Response time (step change): 63.2% of final value in 3 sec; 99.0% in 16 sec; 99.9% in 24 sec (flow at 2 fps).

Price: $900; opt. 001 (50 ft. long waterproof cable): N/C; opt. 002 (armored 50 ft. long waterproof cable with load-bearing termination): add $255 plus $1.50/ft. above 50 ft.

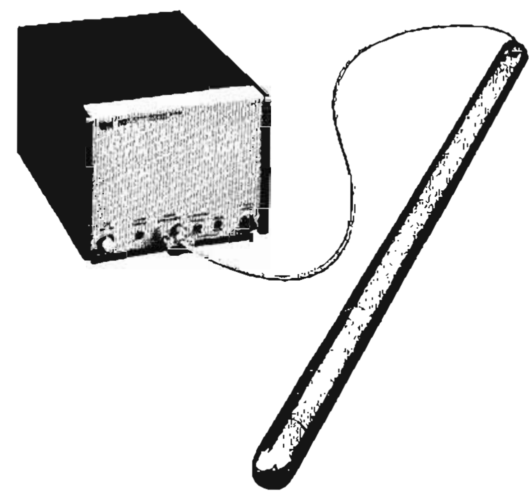
QUARTZ PRESSURE GAUGE

0-12Mpsi, 10 mpsi resolution, remote recording

Model 2811A

The HP 2811A Quartz Pressure Gauge uses a unique transducer consisting of a highly stable quartz crystal resonator whose frequency changes directly with applied pressure. It detects pressure changes as small as 0.01 psi in ambient pressures up to 12,000 psia.

The 2811A consists of a sensing probe and a signal processor interconnected by a standard electric line or cable. The probe and processor can be separated by as much as 30,000 feet of electric line without signal impairment. An electronic counter is used to produce a digital display; any of various recorders, printers, computers or other data handling devices can be connected to the counter output.



Model 2811A Quartz Pressure Gauge uses a unique transducer consisting of a highly stable quartz crystal resonator whose frequency changes directly with applied pressure.

Advantages

The 2811A is intended primarily for use in oil wells as a bottom hole pressure gauge with topside readout. It has a higher resolution and more consistent accuracy over a wider dynamic range than instruments that are presently used in this application. Its 0.01 psi resolution is essentially constant, independent of operating pressure and temperature. The inherent stability of the quartz resonator practically eliminates hysteresis and zero dift, thus eliminating the need for frequent recalibration. In most cases, annual recalibration will be sufficient.

The ruggedness and simplicity of the 2811A Quartz Pressure Gauge greatly facilitate field use. Housed in a 1-7/16" OD case made of stainless steel, the probe can withstand pressures in excess of 20,000 psia. The signal processor requires no adjustments or tuning during operation. An on/off switch and a press-to-test switch are the only controls on the panel. Normal operation is indicated by two indicator lights. Display is achieved by simply connecting the signal processor output to a general purpose digital counter.

A single-conductor coaxial cable (electric line) connects the probe to the signal processor, furnishing all operating power to the probe and transmitting the measurement signal to the processor. The cable is not supplied, but standard one-conductor (with return sheath) electric line can be used in lengths up to 30,000 feet.

Operation

The 2811's probe contains a quartz crystal pressure sensor oscillator and a reference oscillator. The frequency of the sensor oscillator, which varies with pressure, is subtracted from the frequency of the reference oscillator; the resulting difference frequency is transmitted up the cable to the signal processor.

The signal processor, located on the surface, is an amplifier, filter and multiplier which conditions the probe difference frequency to enable it to drive a general purpose electronic counter. The processed output frequency changes about 105 Hz/psi which allows a resolution of 0.01 psi. The signal processor also supplies dc power to the probe in the hole via the electric line.

Specifications

Calibrated pressure range: 0 to 10,000 psi. Within this range the pressure is expressed as a third degree function of the processor output frequency by the following equation:

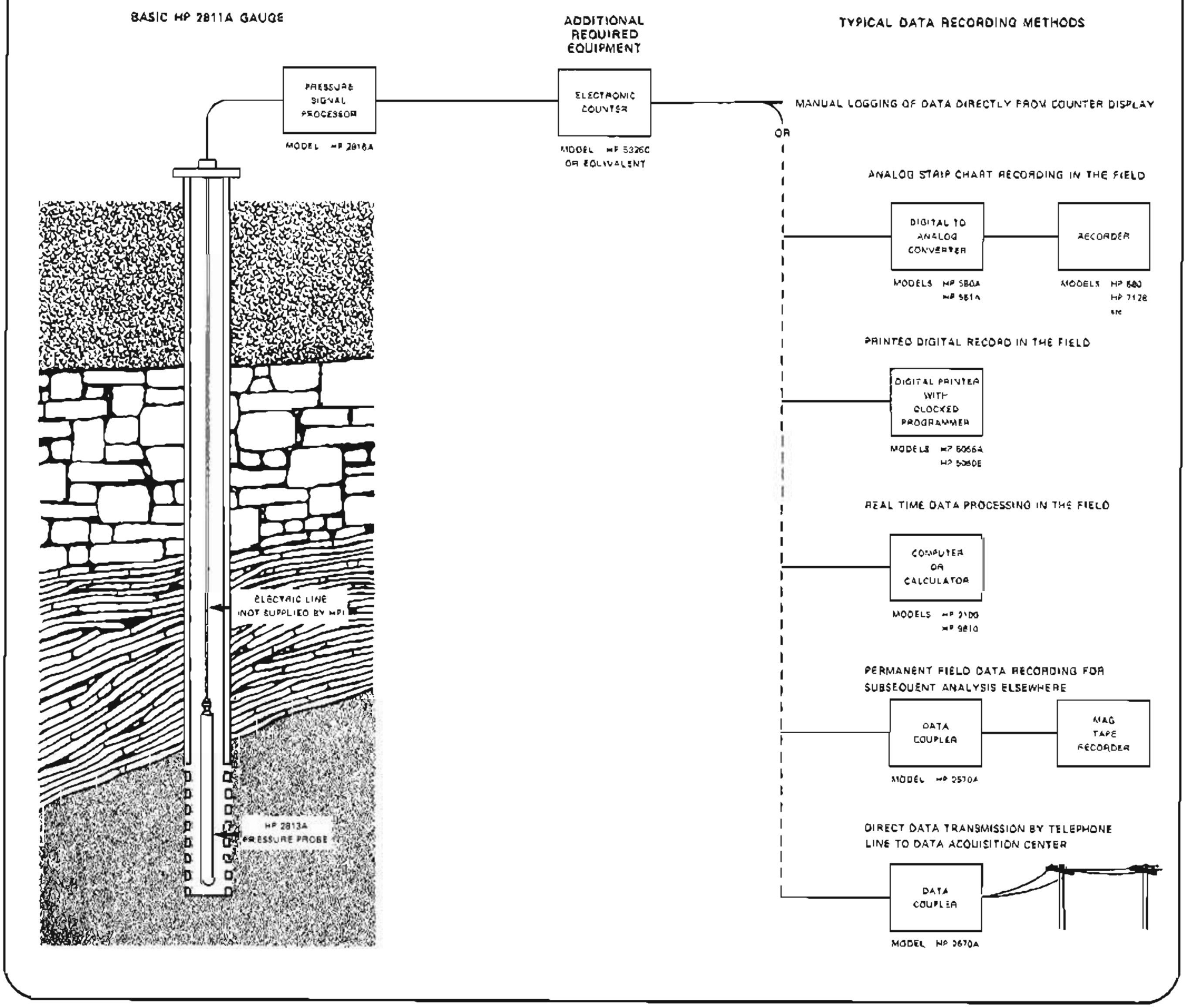
$$P = G + Hf + If^2 + Jf^3$$

where G, H, I and J are provided as functions of temperature from 0°C to 150°C (32°F to 302°F).

Operating temperature range: probe, 0°C to 150°C (32°F to 302°F); signal processor, 0°C to 55°C (32°F to 131°F).

Sensitivity: 105 Hz/psi (nominal) at output of signal processor.

PRESSURE GAUGE SYSTEM CONFIGURATIONS



Resolution: <0.01 psi when sampling for a 1 second period.

Precision: ±0.15 psi over entire range.

Accuracy: (at thermal equilibrium) if operating temperature is known—within 1°C (1.8°F): ±0.25 psi or ±0.025% of reading; within 10°C (18°F): ±1 psi or ±0.1% of reading; within 20°C (36°F): ±5 psi or ±.25% of reading.

Linearity (without calibration): 1% deviation from straight line through frequency at zero pressure and at 10,000 psia.

Stability: annual recalibration recommended.

Signal processor output: nominal square wave with repetition rate between 490 KHz and 1.8 MHz; minimum peak-to-peak amplitude of 1.2 V across 600 ohm load.

Power requirements: 115 or 230 V ac (+10%, −25%) at 48-66 Hz.

Probe connector: mates with 1-7/16" OD Gearhart-Owen single conductor cable-head assemblies (Series 31-1000 and 31-1006) equipped with banana plug end (Part No. 31-1000-20). Other connector configurations quoted upon request.

Cable requirements: total round trip dc resistance ≤500Ω; insulation breakdown voltage ≥50 V.

Probe pressure case: 17-4 PH stainless steel, 1-7/16" OD by 40" long.

Weight: probe, 7 lbs (3,2 kg); signal processor, 7 lbs (3,2 kg).

Price: $8980.

Analog Instruments

Voltage, current and resistance measurements are easy, fast, and accurate with electronic instruments using meter movements. Most electronic voltmeters, ammeters and ohmmeters use rectifiers, amplifiers and other circuits to generate a current proportional to the quantity being measured, which then drives a meter movement. Devices of this type are called analog instruments.

Meter movements—the meter-movement readout should continue to be popular since it is economical and suitable for many jobs. It also lends itself well to special, nonlinear scales such as dB scales. The pivot-jewel suspension has been replaced by taut-band suspension. This has resulted in excellent repeatability with hysteresis virtually eliminated. This repeatability, in turn, makes practical the individually-calibrated meter scale. Both of these improvements are standard in most Hewlett-Packard analog voltmeters.

DC measurements

The dc voltmeter represents a straightforward application of electronics to measuring instruments. This instrument usually has a dc amplifier preceding the meter movement. For most dc current measurements, the meter movement by itself serves the purpose admirably. For lower current measurements, the sensitivity of the meter movement must be increased. Electronic instruments overcome this difficulty by measuring the small voltage drop across a low value resistance placed in series with the current to be measured.

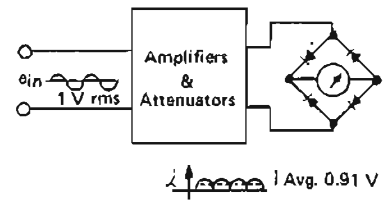
AC voltage measurements

Analog (meter) indicating ac voltmeters fall into three broad categories: average-responding, peak-responding, and rms-responding. AC voltmeters in general use are average and peak-responding types, although rms values are of principal interest.

Average-responding voltmeters

Probably the most widely used measurement technique combining acceptable accuracy and reasonable cost is the average-responding (absolute average) method. Figure 1 shows a typical arrangement for making an average measurement.

The average value of an ac voltage is simply the average value of voltage values measured point by point along the waveform. The average value of a sine wave is really zero, because the waveform has equal positive and negative values when averaged for one whole cycle. Since the equivalent dc or energy content in the waveform usually is the quantity of interest, the average value of a sine wave is taken to mean the average rectified value. The average value of one-half cycle of a sine wave is 0.636 times the peak value.

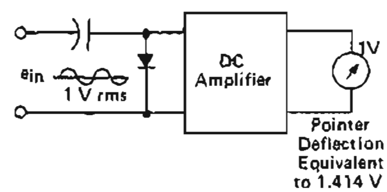


(Figure 1. Average-responding voltmeter.)

The use of average responding is a consequence of the wide use of sine waves in electronic measurements. In calibrating an average responding meter, a pure sine wave with an rms amplitude of 1 volt can be applied to the meter, and the resulting pointer deflection marked on the scale as 1 volt. Actually, the average value of this sine wave is 0.91 volts, but since pointer deflection is linearly proportional to input voltage, an average responding meter calibrated in rms volts provides reliable indications of rms voltage if the input is a sine wave. This indication is not affected more than 3% by as much as 25% second harmonic content in the input waveform, and useful indications are obtained on waveforms with even more distortion. For this reason, average responding voltmeters are widely accepted as low-cost substitutes for true-rms-responding voltmeters, as long as sinusoidal signals are being measured.

Peak-responding voltmeter

There are situations where the peak amplitude of an ac signal is significant, such as the monitoring of a transmitter modulating signal, or in studies of vibration components, or in other situations where peak energy must be known. However, the dominant reason for the use of peak-responding ac voltmeters lies in the nature of their circuitry. Peak-responding circuits allow a voltmeter to serve as a multifunction meter and, what is more important, enables it to be used at much higher frequencies. Here again, since the majority of measurement situations involve sine waves, peak-responding meters usually are calibrated in rms volts. Figure 2 shows a typical arrangement for making a peak measurement. A calibrating sine wave of 1 volt rms amplitude causes a pointer deflection equivalent to 1.414 volts, but this point can be marked as 1 volt rms on the scale. As long as the input waveform is a sine wave, the peak-responding indication is proportional to the rms value. However, the peak-responding meter is more susceptible to errors caused by harmonic distortion in the input waveform than the average responding meter. Another consideration is the maximum sensitivity of the instrument which is limited by the instrument probe diode characteristics. For this reason, careful design is required to achieve even 0.5 volt full scale deflection sensitivity on the lowest range of a peak-responding meter. Conventional voltmeters responding to the absolute average of an ac waveform may sometimes be limited in sensitivity and bandwidth. These restrictions may be relieved by sampling the signal prior to detection and amplification. Hewlett-Packard's RF voltmeter uses a sampling technique (see page 51).



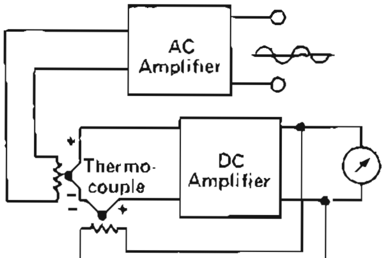
(Figure 2. Peak-responding voltmeter).

For a detailed discussion of the limits of error introduced into peak and average-responding voltmeters by various harmonics, refer to Hewlett-Packard's Application Note 60.

RMS-responding voltmeter

The true-rms measurements technique is most often used when a high degree of accuracy is required. Instrument indication is proportional to the rms heating value of the impressed waveform. The root-mean-square (rms) value of any complex quantity is obtained by summing the squares of each component and taking the square root of the sum; this is defined as the equivalent heating power of the waveform.

This operation is performed by sensing the waveform's heating power. Heating power is measured by feeding an amplified version of an input waveform to



(Figure 3. RMS-responding voltmeter).

the heater of a thermocouple. The voltage output is proportional to the waveform's heating power. The true rms value is measured independently of the waveshape, provided that the peak excursions of the measured waveform does not exceed the dynamic range of the instrument. Harmonic distortion is not an error contributing factor. This arrangement allows accurate readings of the rms value of complex waveforms having high crest factors. Crest factor is defined as the ratio of the peak voltage to the rms voltage of a waveform with the dc component removed. A voltmeter with a high crest factor rating is able to read accurately the rms values of periodic signals that have waveforms significantly different from sinusoidal. High crest factor performance is not obtained easily. An rms voltmeter with a high crest factor must have amplifiers with sufficient dynamic range to pass signals that have a peak amplitude many times larger than full scale rms value. A wide dynamic range is not the only consideration. To prevent thermocouple burn-out, the amplifier design should include some provision for power limiting. Because amplitude limiting would limit the crest factor, the voltmeter must be designed with a limit on the voltage-time product so that thermocouple burn-outs are prevented without restricting wide dynamic range.

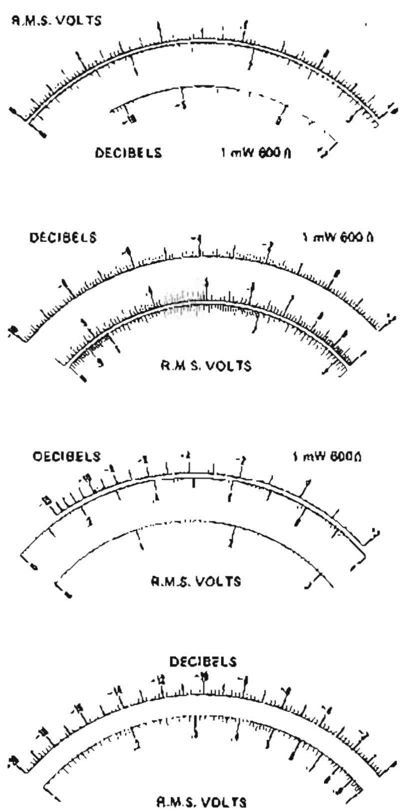


Figure 4. Four different types of meter scales available. (a) Linear 0-3 V and 0-10 V scales plus a dB scale. (b) Linear dB scale plus nonlinear (logarithmic) voltage scales. (c) dB scale placed on larger arc for greater resolution. (d) Linear −20 to 0 dB scale useful for acoustical and communications applications.

In general, true-rms meters reveal only the rms value of an ac signal. Because they are ac coupled, most voltmeters have a frequency cut-off around 20 Hz. This restriction keeps the true-rms voltmeter from accounting for any low frequencies or dc components in a signal. Hewlett-Packard digital voltmeters solve this problem. Refer to pages 71-102.

Voltmeter considerations

Accuracy—Before we can discuss meter accuracy, we must have a familiarity with the various meter scales available. Many instruments have meter scales marked in both volts and decibel (dB) units. It should be noted that dB and voltage are complements of each other. That is, if a voltage scale is made linear, the dB scale on the same meter face will be logarithmic or nonlinear. Likewise, if the dB scale is made linear, the voltage scale becomes nonlinear. The term "linear-log scale" is applied to an instrument that has a linear dB scale and therefore a nonlinear voltage scale. Several different types of meter faces are illustrated in Figure 4.

Analog meters (Figure 5) usually have nonlinearities and/or offsets present in the attenuators and amplifiers. The meter movement itself can have nonlinearities . . . even with individually calibrated meter scales. Nonlinearities cause percent of reading errors, and offsets cause percent of full scale errors. Percent of reading errors are constant no matter where the meter pointer is. Percent of full-scale error increases as the pointer goes further down scale.

Looking at instrument specification sheets, accuracy specifications are usually expressed in one of three ways: 1. (percent of the full-scale value) 2. (percent of the reading) 3. (percent of reading + percent of full-scale). The first is probably the most commonly used accuracy specification. The second (percent of reading) is more commonly applied to meters having a logarithmic scale. The last method has been used more recently to obtain a tighter accuracy specification on a linear-scale instrument.

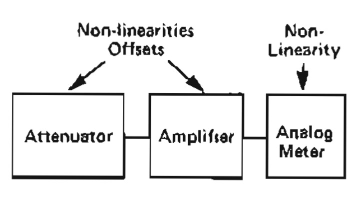


Figure 5. Nonlinearities cause % of reading errors. Offsets cause % of full scale errors.

Hewlett-Packard uses the two-part accuracy specification to take advantage of the upper-scale accuracy and yet maintain a reasonable specification for the lower portion of the scale.

For a thorough evaluation of accuracy, the following should be considered: Does it apply at all input-voltage levels up to maximum overrange point? (Linearity specifications may be added to qualify this point.) Does it apply to all frequencies throughout its specified bandwidth? Does it apply on all ranges? Does it apply over a useful temperature range for the application? If not, is temperature coefficient specified?

Selecting an Analog Voltmeter

Basic specs for Hewlett-Packard analog meters are in Table 1. Guidelines are restated below.

(1) For measurements involving dc applications, select the instrument with the broadest capability meeting your requirements.

(2) For ac measurements involving sine waves with only modest amounts of distortion ($<10\%$), the average-responding voltmeter can perform over a bandwidth extending to several megahertz.

(3) Most broadband average-responding voltmeters are limited in sensitivity (100 μV full-scale) by inherent noise and spurious signals. For ac measurements involving low level signals that may be obscured by noise or other unrelated signals, the tuned voltmeter provides the best accuracy and most sensitivity per dollar (refer to 3410A data sheet).

(4) For high-frequency measurements (>10 MHz), the peak-responding voltmeter with the diode-probe input is the most economical choice. Peak-responding circuits are acceptable if inaccuracies caused by distortion in the input waveform can be tolerated.

(5) For measurements where it is important to determine the effective power of waveforms that depart from a true sinusoidal form, the true rms-responding voltmeter is the appropriate choice.

(6) For very wide bandwidths (up to 1 GHz) and high-sensitivity measurements of sinusoidal or non-sinusoidal waveforms, the HP 3406A is the proper choice. Although the 3406A is average-responding, it has a sample hold output which makes analysis of waveforms possible.

Table 1. HP Analog Instruments

DC VOLTMETERS	Voltage Range	Frequency Range Accuracy at FS*	Input Impedance	Model	See Page
DC NULL VOLTMETER	±3 μV - ±1 kV end scale 0.1 μV resolution (18 ranges)	dc ±2% +1 μV	100 k - 100 MΩ depending on range (infinite when nulled)	419A	46
DC VOLT-AMMETER NEW	DC: ±1 mV, ±300 V 12 ranges ±1 nA, ±300 μA 12 ranges	±3% dc	10 MΩ all ranges	4304B	45
DC DIFFERENTIAL VOLTMETER	1 V to 1 kV (4 ranges)	dc ±(0.002% reading +0.0002% range)	$>10^{11}$ at null	3420B	45
DC DIFFERENTIAL VOLTMETER	1 mV - 1 kV (7 ranges)	dc ±(0.005% rdg +0.0004% rge)	$>10^{10}$	740B	315
AC VOLTMETERS	**Voltage Range**	**Frequency Range Typical Accuracy**	**Response Input Impedance**	**Model**	**See Page**
BATTERY OPERATED AC VOLTMETER	1 mV - 300 V (12 ranges)	1 Hz - 1 MHz ±3% - ±5%	Average 2 MΩ/<25 - <60 pF	403A	52
RECHARGEABLE BATTERY AC VOLTMETER	1 mV - 300 V (12 ranges)	5 Hz - 2 MHz ±2% - ±5%	Average 2 MΩ/<30 - <60 pF	403B	52
VACUUM-TUBE VOLTMETER, also useful as ac amplifier. 400L has linear 12 dB log scale.	1 mV - 300 V - 70 dB - +52 dB (12 ranges)	10 Hz - 4 MHz ±2% to ±10%; 400 H; ±1% to 10%	Average 10 MΩ/20 - 35 pF	400D 400H	53
FAST-RESPONSE AC VOLTMETER 100 kHz low-pass filter ac amplifier	100 μV - 300 V - 90 dB - +52 dB	20 Hz - 4 MHz - ±1% - ±4%	Average 10 MΩ/10 - 25 pF	400F 400FL	54
HIGH ACCURACY dB VOLTMETER 20 dB log scale (0 dB = 1 V)	−100 dB - +60 dB (8 ranges)	20 Hz - 4 MHz - ±0.2 dB - 0.4 dB	Average 10 MΩ/<15 - <30 pF	400GL	54
HIGH ACCURACY AC VOLTMETER has dc output (±0.5%) for driving recorder	1 mV - 300 V - 70 dB - +52 dB	10 Hz - 10 MHz ±1% ±5%	Average 10 MΩ/<12 - <25 pF	400E 400EL	54
RMS VOLTMETER provides rms readings of complex signals. Has dc output for driving DVM'S or recorders	1 mV - 300 V (12 ranges)	10 Hz - 10 MHz ±1% - ±5%	10 MΩ/15 - 40 pF	3400A	55
SAMPLING RF VOLTMETER provides true rms measurements when used with 3400A. Many accessories	1 mV - 3 V (8 ranges)	10 kHz to >1.2 GHz ±3% - ±13%	Statistical Average: Input Z depends on probe tip used	3406A	51
VECTOR VOLTMETER phase and amplitude measurements	100 μV - 10 V (9 ranges)	1 MHz - 1 GHz ±0.5 dB - ±1 dB	Average 0.1 MΩ/2.5 pF	8405A	417
MILLOHMMETER; two probes used when making 4 terminal measurements	0.001 to 100Ω FS (11 ranges)	1 kHz (fixed) ±2% FS	Max. output Voltage: 20 mV	4328A	59
HIGH RESISTANCE METER and picoammeter	0.5 MΩ to 2 x 10^{16}Ω FS (7 ranges) 0.05 pA - 20 μA	Voltage: ±10% Current: ±5%	Max. output Voltage: 1 kV	4329A	60
MULTIFUNCTION METERS	**Voltage Range (Accuracy)**	**Current Range (Accuracy)**	**Resistance Range (Accuracy)**	**Model**	**See Page**
BATTERY-OPERATED MULTIFUNCTION METER has 10 MΩ dc input impedance and 10 MΩ/20 pF ac input impedance	DC: ±100 mV to 1000 V (±2%) 9 ranges AC: 10 mV - 300 V 10 Hz - 1 MHz (±2%) 10 ranges		10Ω-10 MΩ midscale ±5%; from .3 to 3 on the meter scale 7 ranges	427A	49
VERSATILE VOLTMETER has 100 MΩ dc input impedance and 10 MΩ/1.5 pF ac impedance	DC: ±15 mV to ±1500 V (±2%) 11 ranges AC: 0.5 V - 300 V 20 Hz - >700 MHz (±3% at 400 Hz) 7 ranges	DC: ±1.5 μA to ±150 mA (±3%) 11 ranges	10Ω - 10 MΩ (center scale) 0 to midscale: ±5% or ±2% of midscale (whichever is greater) 7 ranges	410C	50
DC VACUUM-TUBE VOLTMETER has 10 MΩ to 200 MΩ input impedance	DC: ±1 mV-±1000 V (±1%) 13 ranges	DC: ±1 μA to ±1A (±2%) 13 ranges	1Ω - 100 MΩ (±5% midscale) 9 ranges	412A	47
DC MICROVOLT-AMMETER has 1 MΩ input impedance (Voltmeter)	DC: ±10 μV - ±1 V (±3%) 11 ranges	DC: ±10 pA to ±3 mA (±3%) 18 ranges		425A	47
CURRENT METERS	**Current Range**	**Accuracy**	**Frequency Range**	**Model**	**See Page**
DC MILLIAMMETER with clip-on probe eliminates direct connection	1 mA - 10 A FS (9 ranges)	±3%	dc - 400 Hz	428B	48
AC CLIP-ON CURRENT PROBE makes measurements without breaking circuit	1 mA - 1 A rms (to 25A with divider)	±2% to 3 dB	25 Hz - 20 MHz	456A	57

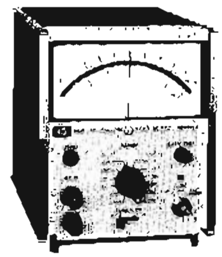
*For exact accuracy refer to page designated.

DC VOLT/AMMETER
20 μV sensitivity, average response
Model 4304B

Description

Hewlett-Packard's Model 4304B is a compact, solid-state dc volt-ammeter. The 4304B can make dc measurements with large amounts of ac signals superimposed on the input.

The 4304B can be used as a dc amplifier with a maximum voltage gain of 60 dB and an accuracy of 1%. The amplifier output is proportional to the meter reading.



4304B

Specifications

DC voltmeter

Ranges: ±1 mV to ±300 V dc, 12 ranges (1, 3, 10, etc.).
Accuracy: ±1.5% of total scale length (±3% of range).
Input resistance: 10 MΩ for all ranges.

DC ammeter

Ranges: ±1 nA to ±300 μA dc in 12 zero center ranges.
Accuracy: ±1.5% of total scale length.
Input resistance: 3.33Ω to 1 MΩ, 1 mV ÷ current range.

DC amplifier

Gain: 1000 (60 dB) on 1 mV range, decreases to 300, 100, 30, etc., corresponding to the range setting.
Accuracy: ±1%.
Output: ±1 V (no load) for end scale reading.
Output resistance: <50Ω.

General

Noise: <20 μV p-p referred to the input.
Ac normal mode rejection: ac voltages >50 Hz and up to 40 dB larger than end scale affects readings <1% of total scale length (2% of range). Peak voltage (sum of ac and dc) not to exceed maximum overload voltage.
Zero shifting: ±110% of end scale on any range.
Power: 115 V or 230 V ±10%, 50 Hz to 60 Hz, approx 2 W.
Dimensions: 5⅛" wide, 6¼" high, 8" deep.

Weight

4304B: 4.8 lbs (2,2 kg); Option 001 5.5 lbs (2,5 kg).

Price

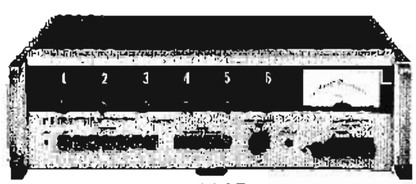
4304B: $410.
Battery Operation, Opt 001: add $33.

Accessories available

11056A Carrying Handle, $5.
04328-7026 rechargeable battery/ac power pack, $62.

DC Δ VOLT/RATIOMETER
1 ppm stability with ±0.002% accuracy
Model 3420B

Specifications, 3420B*



3420B

DC voltmeter

Ranges: ±10 μV to ±1000 V in nine decade ranges.
Accuracy: ±3% of range.
Input resistance: ±10 μV to ±10 mV ranges: 1 MΩ. ±100 mV to 1000 V ranges: 10 MΩ.

DC differential voltmeter

Ranges

Voltage: ±1 V, ±10 V, ±100 V and ±1000 V with up to 10% overranging available on all ranges.
Resolution: six-digit readout yields resolution of 1 ppm of range; 0.2 ppm of range indicated on meter.

Accuracy: (23°C ±1°C, <70% RH).
30 day: ±(0.002% of reading +0.0002% of range).
90 day: ±(0.003% of reading +0.0002% of range).

Stability: (at 23°C ±1°C, <70% RH).
1 hr: <1 ppm of reading.
24 hr: <5 ppm of reading.

Input resistance: 1 V, 10 V, $>10^{11}\Omega$ at null. 100 V, 1 kV, 10 MΩ ±0.05%.

DC ratiometer

Ranges

Ratio: X1, X.1, X.01 and X.001.
Resolution: same as dc Δ VM.

Accuracy: (23°C ±1°C, 70% RH).

30 day: $\pm(0.002\% \text{ of reading} + \frac{0.0004\% \text{ of range})}{E_{(A\ to\ COM)}}$

Stability: (at 23°C ±1°C, <70% RH).
1 hr: <1 ppm of reading. **24 hr:** <5 ppm of reading.
Input: 3 terminals, A, B Common.

$$\text{Displayed Voltage Ratio} = \frac{E_{(B\ to\ COM)}}{E_{(A\ to\ COM)}}$$

with $E_{(A\ to\ COM)} |>| E_{(B\ to\ COM)}|$
and of same polarity

General

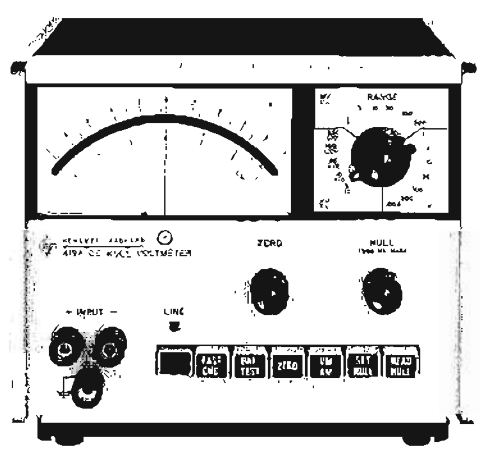
Power: 3420B: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 6 VA max. or rechargeable batteries (eight furnished) 30 hours operating per recharge; input for fast charge mode.
Dimensions: 16¾" wide, 5-7/32" high, 11¼" deep (425 x 132 x 286 mm).
Weight: 3420B: net, 21 lbs (9,3 kg); shipping, 26 lbs (11,7 kg).
Accessories furnished: rack mount kit for 19" rack.
Price: HP 3420B, $1825.

* Refer to data sheet for complete specifications.

DC NULL VOLT-AMMETER

18 Voltage, 7 current ranges; 0.1 μV resolution

Model 419A



419A

Eighteen voltage ranges with 0.1 μV resolution on the lowest range set this HP solid-state DC Null Voltmeter apart from previous dc null meters. The accuracy of this rechargeable battery-operated instrument is ±2% of end scale ±0.1 μV on all ranges. Noise is less than 0.3 μV p-p, and drift is less than 0.5 μV/day.

An internal nulling voltage allows input voltages up to 300 mV to be nulled giving an infinite input impedance. Input impedance above the 300 mV range is 100 megohms.

Pushbutton Selection Provides Convenience-versatility

Seven pushbuttons allow the operator to select rapidly the desired function of the HP 419A. This dc null voltmeter operates from the ac line or from the internal rechargeable batteries. During operation from the ac line, the batteries are trickle-charged. A fast-charge pushbutton is provided to increase the charging rate, recharging the batteries in approximately 16 hours. Battery voltage may be easily checked with the battery-test pushbutton. The zero pushbutton enables the operator to compensate for any internal offsets before making a measurement. When this pushbutton is depressed, the positive leg of the voltmeter is disconnected from the positive input terminal and connected to the negative input terminal.

When the VM pushbutton is depressed, the HP 419A functions as a zero-center scale 3 μV to 1000 V dc voltmeter.

When the AM pushbutton is depressed, the HP 419A functions as a zero-center scale 30 pA to 30 nA ammeter.

Specifications

DC null voltmeter

Ranges: ±3 μV to ±1000 V dc in 18 zero-center ranges.

Accuracy: ±(2% of range ±0.1 μV).

Zero control range: >±15 μV.

Zero drift: <0.5 μV/day after 30 min warm-up.

Zero temperature coefficient: <0.05 μV/°C.

Response time: 3 s to within 95% of final reading on 3 μV range; 1 s to within 95% of final reading on 10 μV to 1000 V ranges.

Noise: <0.3 μV p-p, input shorted.
[Noise amplitude approximates Gaussian distribution. RMS value (standard deviation) is <0.075 μV, p-p noise value is <0.3 μV 95% of the time.]

Input characteristics

At null: infinite resistance on 3 μV through 300 mV ranges in SET NULL mode. Negative input terminal can be floated up to ±500 V dc from powerline ground.

Off null:

Voltage range	Input resistance
3 μV - 3 mV	100 kΩ
10 mV - 30 mV	1 MΩ
100 mV - 300 mV	10 MΩ
1 V - 1000 V	100 MΩ

Negative input terminal can be floated up to ±500 V dc from powerline ground.

AC normal-mode rejection: ac voltages 50 Hz and above and 80 dB greater than end scale affect reading <2%. Peak ac voltage not to exceed maximum overload voltage.

DC ammeter

Ranges: ±30 pA to ±30 nA in 7 zero-center ranges.

Accuracy: ±(3% of range +1 pA).

Zero control range: >±150 pA.

Zero drift: <5 pA/day after 30 min warm-up.

Zero temperature coefficient: <0.5 pA/°C.

Noise: <3 pA p-p, input shorted.

Input resistance: 100 kΩ on all ranges.

Amplifier

Gain: 110 dB on 3 μV range, decreases 10 dB per range.

Output: 0 to ±1 V at 1 mA maximum for end-scale reading. Output level adjustable for convenience when used with recorders.

Output resistance: depends on setting of output level control. <35Ω when output control is set to maximum.

Noise: 0.01 Hz to 5 Hz: same as voltmeter (referred to input). >5 Hz: <10 mV rms (referred to output).

General

Overload protection: the following voltages can be applied without damage to instrument.

1 V to 1000 V range: 1200 V dc.

10 mV to 300 mV range: 500 V dc.

3 μV to 300 mV range: 50 V dc.

Operating temperature: instrument will operate within specifications from 0°C to 50°C.

Operating humidity: <70% RH.

Storage temperature: −20°C to +50°C.

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 2 VA max. or 4 internal rechargeable batteries (furnished). 30-hr operation per recharge. Operation from ac line permissible during recharge.

Dimensions: 7¾″ wide, 6¼″ high (without removable feet), 8″ deep (197 x 156 x 203 mm).

Weight: net, 8.3 lb (3,7 kg); shipping, 12 lb (5,4 kg).

Price: HP 419A, $595.

DC VOLT-OHM-AMMETER
1 mV to 1 kV; 1 μA to 1 A; 1Ω to 100 MΩ
Model 412A

Description

The HP Model 412A is a multipurpose meter designed to measure dc voltage, current, and resistance with laboratory accuracy.

Specifications

Voltmeter

Voltage range: pos. and neg. voltages from 1 mV to 1000 V full scale, 13 ranges.

Accuracy: ±1% of full scale on any range.

Input resistance: 10 MΩ ±1% on 1 mV, 3 mV and 10 mV ranges; 30 MΩ ±1% on 30 mV range; 100 MΩ ±1% on 100 mV range; 200 MΩ ±1% on 300 mV range and above.

AC rejection: a voltage at power line or twice power line frequency 40 dB > full scale affects reading <1%. Peak voltage must not exceed 1500 V.

Ammeter

Current range: pos. and neg. currents from 1 μA to 1 A full scale, 13 ranges.

Accuracy: ±2% of full scale on any range.

Input resistance:* decreasing from 1000Ω on 1 μA range to 0.1Ω on 1 A range.

Ohmmeter

Resistance range: resistance from 1Ω to 100 MΩ center scale, 9 ranges.

Accuracy: ±5% of reading at center scale.

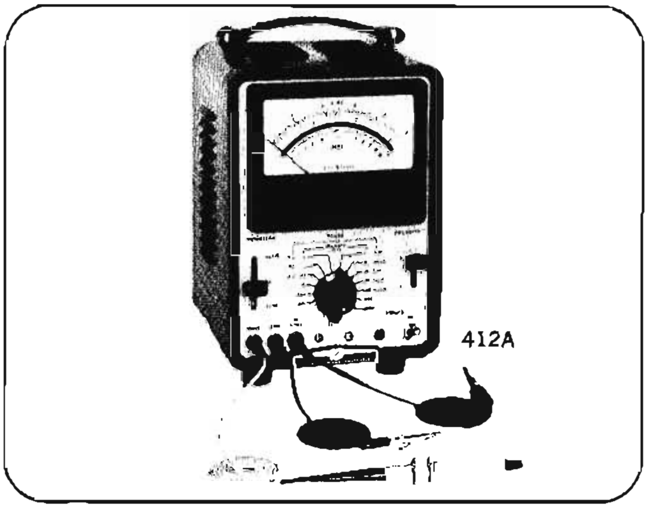
Short circuit current:* from 0.01 μA on the X100 MΩ range to 10 mA on the 1Ω range.

Amplifier*

Voltage gain: 1000 maximum.

DC bandwidth: dc to 0.7 Hz on all voltage ranges.

* Refer to data sheet for complete specifications.



Output: proportional to meter indication; 1 V at full scale; max. current, 1 mA (full scale corresponds to 1 on upper scale).

General

Power: 115 or 230 V ±10%, 50 to 60 Hz, 60 VA max.

Dimensions: cabinet: 7½" wide, 11½" high, 10" deep (191 x 292 x 254 mm); rack mount: 19" wide, 5-7/32" high, 7½" deep behind panel (483 x 134 x 191 mm).

Weight: net: 12 lbs (5,5 kg); shipping 14 lbs (6,4 kg) (cabinet); net 12 lbs (5,5 kg); shipping: 21 lbs (9,5 kg) (rack mount).

Price: HP 412A, $525 (cabinet).
HP 412AR, $535 (rack mount).

DC MICROVOLT-AMMETER
10 μV, 10 pA full scale sensitivity
Model 425A

Description

Hewlett-Packard's 425A, DC Microvolt-Ammeter, makes measurements of extremely small dc voltages from 1 μV to 1 V; dc currents, from 1 pA to 3 mA.

Specifications

Microvolt-ammeter

Voltage range: pos. and neg. voltages from 10 μV end scale to 1 V end scale, 11 steps, 1, 3, 10 sequence.

Current range: pos. and neg. currents from 10 pA end scale to 3 mA end scale, 18 steps, 1, 3, 10 sequence.

Input impedance: voltage ranges, 1 MΩ ±3%; current range, depends on range, 1 MΩ to 0.33Ω.

Accuracy: within ±3% of range; line frequency variations ±5 Hz affect accuracy <±2%.

Amplifier*

Gain: 100,000 maximum.

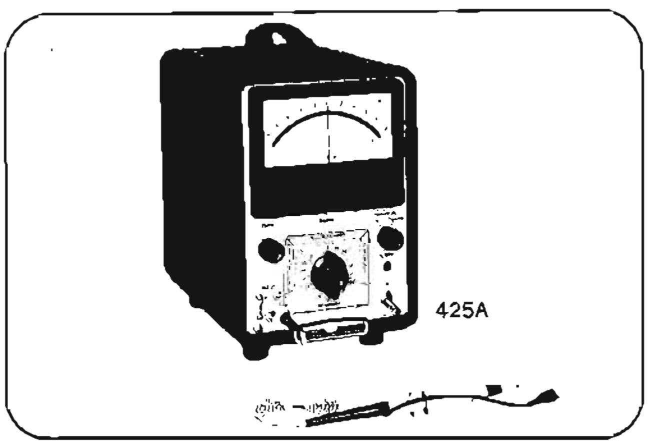
DC bandwidth:

dc to 0.1 Hz on 10 μV range.
dc to 0.3 Hz on 30 μV range.
dc to 0.7 Hz on 100 μV range and above.

Output: 0 to 1 V for end-scale reading, adjustable (5000Ω shunt potentiometer), 1 mA maximum at 1 V output.

General

Power: 115 or (230 V must be specified) ±10%, 60 Hz, 50 VA max.; 50 Hz operation is available as option 001.



Dimensions: cabinet: 7⅜" wide, 11¾" high, 12" deep (186 x 299 x 305 mm); rack mount: 19" wide, 7" high, 11" deep behind panel (483 x 178 x 279 mm).

Weight: net 17 lbs (7,7 kg); shipping 18 lbs (8,2 kg) (cabinet); net 21 lbs (9,5 kg); shipping 31 lbs (14 kg) (rack mount).

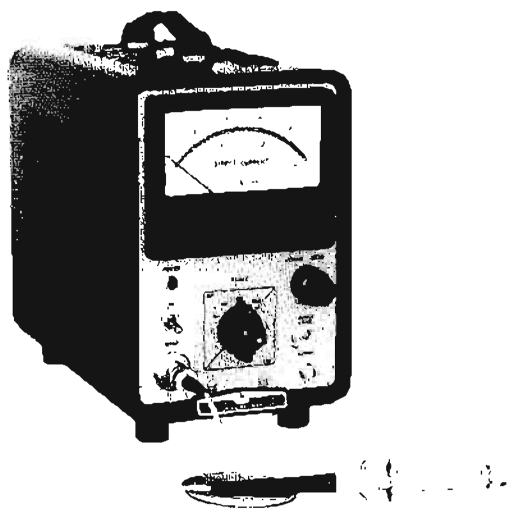
Price: HP 425A, $695 (cabinet). HP 425A Option 001, for operation from 50 Hz power, no extra charge.

* Refer to data sheet for complete specifications.

CLIP-ON MILLIAMMETER

Measures current from 1 mA to 10 A full scale

Model 428B and probes



428B

Description

Direct current from 0.02 milliampere to 10 amperes can be measured with the HP 428B without interrupting the circuits and without the error-producing loading of conventional methods.

For any measurement of dc within its range, simply clamp the jaws of the 428B around a wire and read.

This ease and speed of operation are unparalleled, especially for applications where many dc measurements must be made. Wide current range of the 428B will handle most signals directly. For even greater sensitivity, several loops may be put through the probe, increasing the sensitivity by the same factor as the number of loops.

In addition to making current measurements directly, the 428B is also valuable for measuring sums and differences of currents in separate wires. When the probe is clipped around two wires carrying current in the same direction, their sum is indicated on the meter; when one of the wires is reversed, their difference is measured. Thus, current balancing is possible by obtaining a zero difference reading.

Model 428B provides an output voltage proportional to the measured current, which is useful for driving recorders or making low-frequency (dc to 400 Hz) current measurements.

Specifications

DC current range: 1 mA to 10 A full scale, nine ranges.

Accuracy: ±3% of full scale ±0.15 mA, from 0°C to 55°C (when instrument is calibrated to probe).

Probe inductance: <0.5 μH.

Probe inducted voltage: <15 mV p (worst case at 20 kHz and harmonics).

Output: variable linear output level with switch position for calibrated 1 V into open circuit (corresponds to full scale deflection). 1.5 V max. into open circuit in uncalibrated position. 0.73 ±.01 V into 1 kΩ in calibrated position.

Noise: 1 mA range, <15 mV rms across 1 kΩ.
3 mA range, <5 mV rms across 1 kΩ.
10 mA through 10 A ranges, <2 mV rms across 1 kΩ.

Frequency range: dc to 400 Hz (3 dB point).

AC rejection: signals above 5 Hz with p value < full scale affect meter accuracy <2% (except at 40 kHz carrier frequency and its harmonics). On the 10 A range, ac p value is limited to 4 A.

Power: 115 or 230 V ±10%, 50 to 60 Hz, approx. 75 VA max.

Operating temperature range: −20°C to +55°C.

Storage temperature: −40°C to +65°C.

Probe insulation: 300 V maximum.

Probe tip size: approximately ½" by 21/32"; aperture diameter 5/32".

Dimensions: 7½" wide, 11½" high, 14½" deep (191 x 292 x 368 mm); rack mount: 19" wide, 6-31/32" high, 13" deep (483 x 177 x 330 mm).

Weight: net 19 lbs (8,6 kg), shipping 24 lbs (10,9 kg) (cabinet); net 24 lbs (10,8 kg); shipping 32 lbs (14,4 kg) (rack mount).

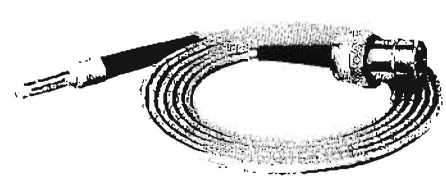
Price: HP 428B, (cabinet) $675 ; HP 428BR, (rack mount) $680 .

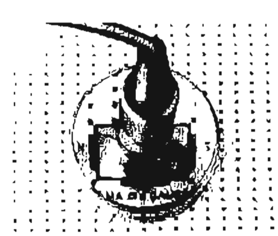
Accessories Available

3529A Magnetometer Probe

The HP 3529A Magnetometer Probe is useful in applications where determination must be made of the direction or magnitude of a magnetic field. It is useful in applications ranging from acoustical transducer design to investigations involving the Zeeman effect. Conversion factor is 1:1, producing a reading on the 428B in milliamperes which is directly equal to the measured field strength in milligauss. Range is 1 milligauss to 10 gauss with the 428B. The bandwidth is dc to 80 Hz, and accuracy is ±3% of full scale when the probe is calibrated with the instrument.

Price: HP 3529A, $95.





3529A option C11

3529A Option C11 Magnetometer Probe

The 3529A Option C11 is a special magnetometer probe used to convert the Hewlett-Packard Model 428B DC Milliammeter into a direct reading magnetometer (1 G = 1 mA indication on the meter). The 3529A Option C11 Magnetometer Probe is specifically designed to measure the relative magnetic field strength of individual bar magnets on twistor memory cards used in the Western Electric Electronic Switching System (No. 1ESS). Refer to data sheet for further information.

Price: HP 3529A, Option C11, $170.

MULTI-FUNCTION METER
Low-cost, solid state, battery operated
Model 427A

Description

The Hewlett-Packard Model 427A is a portable, versatile, low cost multi-function meter which is valuable in any laboratory, production line, service department, or in the field. It is capable of measuring dc voltages from 100 mV to 1 kV full scale; ac voltage from 10 mV to 300 V full scale at frequencies up to 1 MHz (>500 MHz with the 11096A High Frequency Probe); and resistance from 10Ω to 10 MΩ center scale.

The 427A will operate continuously for more than 300 hours on its internal 22.5 V dry cell battery. AC line and battery operation is available as an option.

Specifications

DC voltmeter

Ranges: ±100 mV to ±1000 V in 9 ranges in 10 dB steps.
Accuracy: ±2% of range.
Input resistance: 10 MΩ.
AC normal-mode rejection (ACNMR): ACNMR is the ratio of the normal-mode signal to the resultant error in readout. 50 Hz and above: >80 dB.
Overload protection: 1200 V dc.

AC voltmeter

Ranges: 10 mV to 300 V in 10 ranges in 10 dB steps.
Frequency range: 10 Hz to 1 MHz.
Response: responds to average value, calibrated in rms.
Accuracy

Frequency	Range	
	0.01 V to 30 V	100 V to 300 V
10 Hz to 100 kHz	2% of range	2% of range
100 kHz to 1 MHz		

Input impedance: 10 mV to 1 V range, 10 MΩ shunted by <40 pF; 3 V to 300 V range, 10 MΩ shunted by <20 pF.
Overload protection: 300 V rms momentarily, 1 V range and below; 425 V rms max. above 1 V range.

Ohmmeter

Ranges: 10Ω to 10 MΩ center scale in 7 decade ranges.
Accuracy (from 0.3 to 3 on scale): ±5% of reading.
Source current (ohms terminal positive). Short circuit current: from 10 mA on the X10 range to 0.1 μA on the X10 M range.
Open circuit voltage: from 0.1 V on the X10 range to 1 V on the X10 M range.

General

Input: may be floated up to ±500 V dc above chassis ground. Ohms input open in any function except ohms. Volts input open when instrument is off.

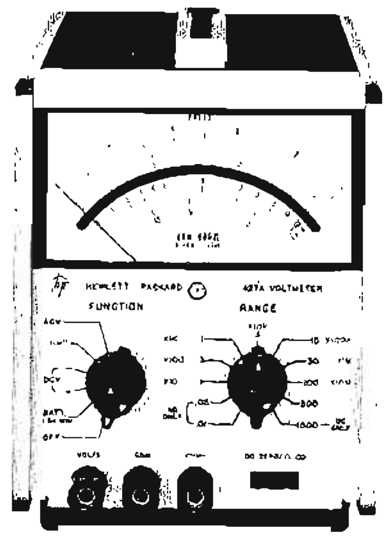
Operating temperature: 0°C to 50°C.

Power: >300-hr operation per battery.
HP 427A: 22.5 V dry cell battery, Eveready No. 763 or RCA VS102. HP 427A Option 001: battery operation or ac line operation, selectable on rear panel. 115 V or 230 V ±20% 48 Hz to 440 Hz, 2 VA max.

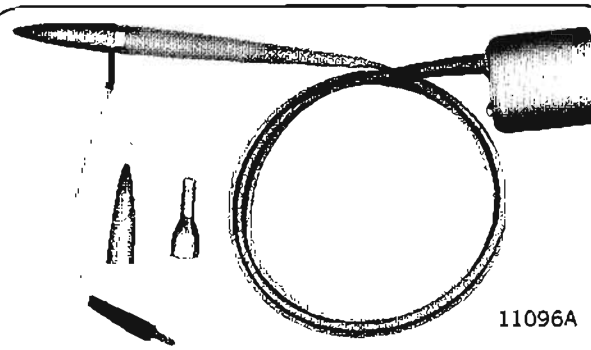
Dimensions (standard 1/3 module): 5⅛" wide, 6¼" high (without removable feet), 8" deep (130 x 159 x 203 mm).

Weight: net, 5.3 lb (2,4 kg); shipping, 8 lb (3,6 kg).

Price (includes battery): HP 427A, $295.
HP 427A Option 001, add $25.



427A



11096A

Accessories available

HP 11096A High Frequency AC Probe extends range to >500 MHz. With the 11096A you can measure 0.25 to 30 V rms signals out to 500 MHz with better than ±1 dB accuracy. Usable relative measurements can be made up to 1 GHz (3 dB point at 700 MHz). The 11096A is a peak-responding detector calibrated to produce a dc output proportional to the rms value of a sine wave input. Input impedance is 4 MΩ shunted by 2 pF.
Price: HP 11096A, $75.

HP 11075A *High Impact Case. A rugged case for carrying,* storing and operating the 427A, $60.

HP 11001A 45" test lead, dual banana plug to male BNC, $13.

HP 11002A 60" test lead, dual banana plug to alligator clips, $10.

HP 11003A 60" test lead, dual banana plug to pencil probe and alligator clip, $10.

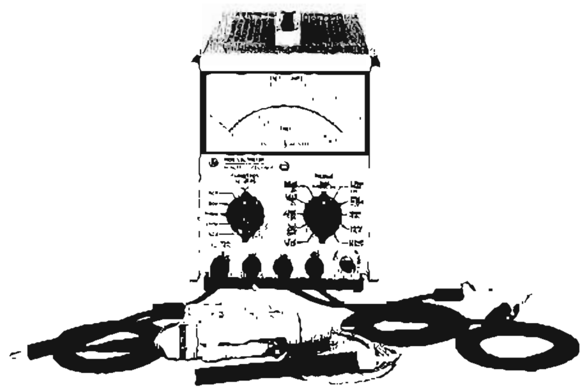
HP 11039A 1000: 1 capacitive voltage divider, 25 kV max, $250.

HP 10111A BNC female to dual banana adapter, $10.

MULTIFUNCTION VOLTMETER

All-purpose instrument measures to 700 MHz

Model 410C



410C

Description

The HP Model 410C is a versatile general purpose instrument for use anywhere electrical measurements are made. This one instrument measures dc voltages from 15 mV to 1500 V, direct current from 1.5 μA to 150 mA full scale, and resistance from 0.2 Ω to 500 MΩ. With a standard plug-in probe, ac voltages at 20 Hz to 700 MHz from 50 mV to 300 V and comparative indications to 3 GHz are attainable.

410C Specifications

DC voltmeter

Voltage ranges: ±15 mV to ±1500 V full scale in 15, 50 sequence (11 ranges).

Accuracy: ±2% of full scale on any range.

Input resistance: 100 MΩ ±1% on 500 mV range and above. 10 MΩ ±3% on 150 mV range and below.

AC voltmeter

Voltage ranges: 0.5 V to 300 V full scale in 0.5, 1.5, 5 sequence (7 ranges).

Frequency range: 20 Hz to 700 MHz.

Accuracy: ±3% of full scale at 400 Hz for sinusoidal voltages from 0.5 V to 300 V rms. The ac probe responds to the positive peak-above-average value of the applied signal. The meter is calibrated in rms.

Frequency response: ±2% from 100 Hz to 50 MHz (400 Hz ref.); 0 to −4% from 50 MHz to 100 MHz; ±10% from 20 Hz to 100 Hz and from 100 MHz to 700 MHz.

Input impedance: input capacitance 1.5 pF, input resistance >10 MΩ at low frequencies. At high frequencies impedance drops off due to dielectric loss.

Safety: the probe body is grounded to chassis at all times for safety. All ac measurements are referenced to chassis.

DC ammeter

Current ranges: ±1.5 μA to ±150 mA full scale in 1.5, 5 sequence (11 ranges).

Accuracy: ±3% of full scale on any range.

Input resistance: decreasing from 9 kΩ on 1.5 μA range to approximately 0.3 Ω on the 150 mA range.

Special current ranges: ±1.5, ±5 and ±15 nA may be measured on the 15, 50 and 150 mV ranges using the dc voltmeter probe, with ±5% accuracy and 10 MΩ input resistance.

Ohmmeter

Resistance range: resistance from 10 Ω to 10 MΩ center scale (7 ranges).

Accuracy: Zero to midscale: ±5% of reading or ±2% of midscale, which ever is greater.
±7% from midscale to scale value of 2.
±8% from scale value of 2 to 3.
±9% from scale value of 3 to 5.
±10% from scale value of 5 to 10.

Amplifier

Voltage gain: 100 maximum.

AC rejection: 3 dB at 0.5 Hz; approximately 66 dB at 50 Hz and higher frequencies for signals <1600 V p or 30 times full scale, whichever is smaller.

Isolation: impedance between common and chassis is >10 MΩ in parallel with 0.1 μF. Common may be floated up to 400 V dc above chassis for dc and resistance measurements.

Output: proportional to meter indication; 1.5 V dc at full scale, maximum current, 1 mA.

Output impedance: <3 Ω at dc.

Noise: <0.5% of full scale on any range (p-p).

DC drift: <0.5% of full scale/yr at constant temperature; <0.02% of full scale/°C.

Overload recovery: recovers from 100:1 overload in <3 s.

General

Maximum input: (see overload recovery) dc: 100 V on 15, 50 and 150 mV ranges, 500 V on 0.5 to 15 V ranges, 1600 V on higher ranges. ac: 100 times full scale or 450 V p whichever is less.

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 26 VA max.

Dimensions: 5⅛" wide, 6¼" high (without removable feet), 11" deep (130 x 159 x 279 mm) behind panel.

Weight: net 8 lb (4 kg); shipping 12 lb (5,44 kg).

Accessories furnished: detachable power cord, NEMA plug.

Accessories available: see page 57.

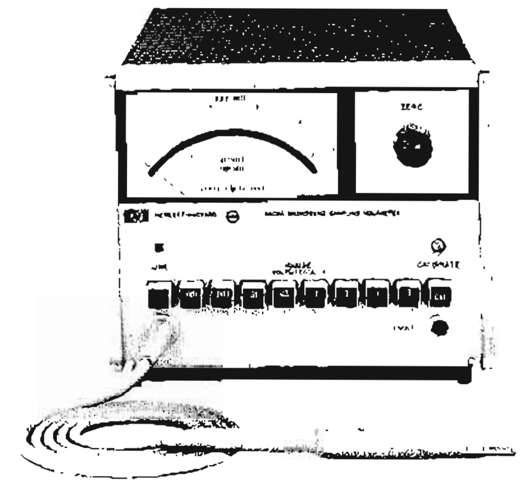
Price: HP 410C with HP 11036A Detachable AC Probe, $585.
410C Option 002 (less ac probe), $50.

RF VOLTMETER
20 μV sensitivity; 10 kHz to 1.2 GHz
Model 3406A

Description

High frequency voltages can be measured easily with HP's 3406A Sampling Voltmeter. Employing incoherent sampling techniques, the HP 3406A has extremely wide bandwith (10 kHz to 1.2 GHz) with high input impedance. Signals as small as 50 μV can be resolved on the sampling voltmeter's linear scale. Full scale sensitivity from 1 mV to 3 V is selected in eight 10 dB steps and may be read directly from −62 dBm to +23 dBm for power measurements. Accessory probe tips make the HP 3406A suitable for voltage measurements in many applications such as receivers, amplifiers and coaxial transmission lines.

Measurement indications can be retained on the 3406A meter by depressing a push-button located on the pen-type probe. This feature is useful when measurements are made in awkward positions where the operator cannot observe the meter indication and probe placements at the same time. Other features include a dc recorder output and sample hold output for connection to oscilloscopes, and peak or true rms voltmeters if other than absolute average measurements are required.



3406A

Specifications

Voltage range: 1 mV to 3 V full scale in 8 ranges; decibels from −50 to +20 dBm (0 dBm = 1 mW into 50Ω); average-responding instrument calibrated to rms value of sine wave.

Frequency range: 10 kHz to 1.2 GHz; useful sensitivity from 1 kHz to beyond 2 GHz.

Full-scale accuracy (%) with appropriate accessory (after probe is properly calibrated)

10 kHz	20 kHz	25 kHz	100 kHz	100 MHz	700 MHz	1 GHz	1.2 GHz
±13	±8	±5	±3	±5	±8	±13	

Input impedance: input capacity and resistance will depend upon accessory tip used. 100,000Ω shunted by <2.1 pF at 100 kHz with bare probe; <10 pF with 11072A isolator tip supplied.

Sample hold output

Provides ac signal whose unclamped portion has statistics that are narrowly distributed about the statistics of the input, inverted in sign (operating into >200 kΩ load with <1000 pF). Output is 0.316 V at f.s. on any range.

Noise: <175 μV rms referred to input.

Accuracy (after probe is properly calibrated): 0.01 V range and above: same as full scale accuracy of instrument.

0.001 V to 0.003 V range: value of input signal can be computed by taking into account the residual noise of the instrument.

Jitter: meter indicates within ±2% p of reading 95% of time (as measured with HP 3400A True RMS Voltmeter).

RMS crest factor: 0.001 V to 0.3 V, 20 dB; 1 V, 13 dB; 3 V, 3 dB.

Meter

Meter scales: linear voltage, 0 to 1 and 0 to 3; decibel, −12 to +3. Individually calibrated taut-band meter.

Response time: indicates within specified accuracy in <3 s.

Jitter: ±1% peak (of reading).

General

DC recorder output: adjustable from 0 to 1.2 mA into 1000 ohms at full scale, proportional to meter deflection.

Overload recovery time: meter indicates within specified accuracy in <5 s (30 V p-p max.).

Maximum input: ±100 V dc, 30 V p-p.

RFI: conducted and radiated leakage limits are below those specified in MIL-6181D and MIL-1-16910C except for pulses emitted from probe. Spectral intensity of these pulses are nominally 50 nV/$\sqrt{Hz}$; spectrum extends beyond 2 GHz.

Temperature range: instrument, 0°C to +55°C; probe, +10°C to +40°C.

Power: 115 or 230 V ±10%, 48 Hz to 440 Hz, 25 VA max.

Dimensions: 7¾" wide, 6¼" high (without removable feet), 11" deep (197 x 159 x 279 mm); ½ module.

Weight: net 12 lbs (5,4 kg); shipping 15 lbs (6,8 kg).

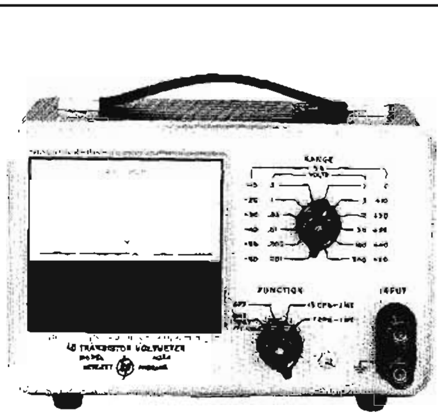
Accessories: refer to data sheet.

Price: HP 3406A, $850.

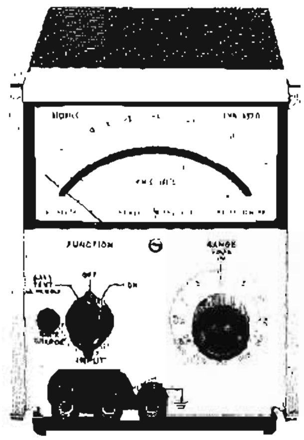
AC VOLTMETERS

Solid-state, battery-operated, portable

Model 403A, 403B



403A



403B

Description

Models 403A and 403B ac voltmeters are versatile, general purpose instruments for laboratory and production work and are ideal for use in the field since they are solid-state, battery-operated, and portable.

Both measure from 100 microvolts to 300 volts, the 403A covering 1 Hz to 1 MHz and the 403B covering 5 Hz to 2 MHz. Both operate from internal batteries and thus may be completely isolated from the power line and external grounds, permitting accurate measurements at power-line frequency and its harmonics without concern for beat effects. Isolation from external ground also permits use where ground loops are troublesome. Turnover effect and waveform errors are minimized because the meters respond to the average value of the input signal.

The 403B operates from an ac line as well as from the internal battery pack, and batteries recharge during ac operation. Battery charge may be easily checked with a front-panel switch to assure reliable measurements. Normally, about 60 hours of ac operation recharge the batteries; but an internal adjustment is provided which nearly doubles the charging rate. The Model 403B can be used while its batteries charge. A sturdy taut-band meter eliminates friction and provides greater precision and repeatability.

For improved resolution in dB measurements, the 403B option 001 is available. This version spreads out the dB scale by making it the top scale of the meter.

Specifications

HP Model	403A	403B	403B Option 001
Range	0.001 to 300 V rms full scale, 12 ranges, in a 1, 3, 10 sequence. —60 dB to +50 dB in 12 ranges with 10 dB steps.		
Meter	responds to average value of input waveform, calibrated in the rms value of a sine wave.		
Frequency range	1 Hz to 1 MHz	5 Hz to 2 MHz	5 Hz to 2 MHz
Accuracy	within ±3% of full scale, 5 Hz to 500 kHz; within ±5% of full scale, 1 to 5 Hz and 500 kHz to 1 MHz	within ±2% of full scale from 10 Hz to 1 MHz; within ±5% of full scale from 5 to 10 Hz and 1 to 2 MHz, except ±10% 1 to 2 MHz on the 300 V range (0 to 50°C)*	within ±0.2 dB of full scale from 10 Hz to 1 MHz; within ±0.4 dB of full scale from 5 to 10 Hz and 1 to 2 MHz, except ±0.8 dB 1 to 2 MHz on the 300 V range (0 to 50°C)*
Input Impedance	2MΩ shunted by <60 pF, 0.001 to 0.1V ranges; 2MΩ shunted by <25 pF on 0.3 to 300 V ranges	2MΩ; shunted by <60 pF; 0.001 to 0.03 V ranges; <30 pF, 0.1 to 300 V ranges	same as 403B
Maximum input	600 Vp, 0.3 V and higher ranges; 25 V rms or 600 Vp on 0.1 V and lower ranges (fused).	Fuse protected (signal ground can be ±500 V dc from chassis).	same as 403B
Power	5 standard radio-type mercury cells. Battery life approx. 400 hours	4 rechargeable batteries, 40 hr' operation per recharge, up to 500 recharging cycles; self-contained recharging circuit functions during operation from ac line	same as 403B
Dimensions	8¼" wide, 5½" high, 6⅜" deep (210 x 140 x 162 mm)	5⅛" wide, 6¼" high (without removable feet), 8" deep (130 x 159 x 203 mm)	same as 403B
Weight	net 4¾ lbs (2,1 kg); shipping 8 lbs (3,6 kg)	net 6½ lbs (2,9 kg); shipping 8 lbs (3,6 kg)	same as 403B
Price	$380	$350	$375

*Use 10001A 10:1 Divider and 10111A Adapter to retain ±5% (±0.4 dB) accuracy while measuring up to 425 V rms at 1 to 2 MHz.

VACUUM TUBE VOLTMETERS
10 Hz to 4 MHz
Models 400D, 400H

400D

400H

Description

Model 400D is a precision voltmeter offering wide voltage range, 2% accuracy, and the broad frequency coverage of 10 Hz to 4 MHz.

Model 400H is similar to Model 400D, having individual meter-face calibration and 1% on an extra large 5" mirror-scale meter.

Other features common to these two voltmeters include 10 MΩ input impedance, overload protection to 600 V, and output circuitry permitting the voltmeters to be used as broadband, high gain amplifiers throughout their frequency range.

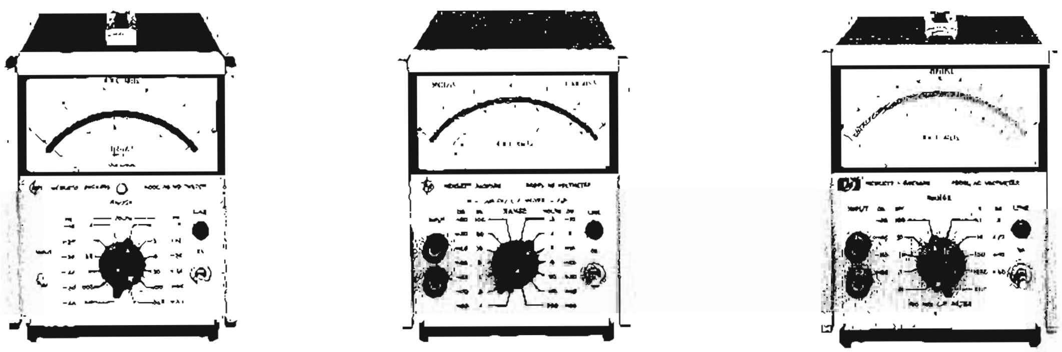
Special dB-measuring options

As normally supplied, Models 400D and 400H read direct in volts and dB, with the voltage scale uppermost. For greater resolution in dB measuring, these instruments are available as Models 400D Option 001, and 400H Option 001 with the dB meter scale uppermost.

Specifications

	400D,DR	400H,HR
Voltage range:	1.0 mV to 300 V full scale, 12 ranges	1.0 mV to 300 V full scale, 12 ranges
Frequency range:	10 Hz to 4 MHz	
Accuracy:	10 Hz to 20 Hz: ±10% f.s. 20 Hz to 1 MHz: ±2% f.s. 1 MHz to 2 MHz: ±3% f.s. 2 MHz to 4 MHz: ±10% f.s.	10 Hz to 20 Hz: ±10% f.s. 20 Hz to 50 Hz: ±2% f.s. 50 Hz to 500 kHz: ±1% f.s. 500 kHz to 1 MHz: ±2% f.s. 1 MHz to 2 MHz: ±3% f.s. 2 MHz to 4 MHz: ±10% f.s.
Calibration:	reads rms value to sine wave; voltage indication proportional to average value of applied wave; linear voltage scale 0 to 3 and 0 to 1; dB scale −12 to +2 dB (0 dB = 1 mW in 600Ω); 10 dB interval between ranges	
Input impedance:	10 MΩ shunted by <20 pF on ranges 1 to 300 V; <35 pF on ranges 0.001 to 0.3 V	
Amplifier:	output 0.15 V max.; output impedance 50Ω; max. gain 150 on 0.001 range	
Power:	115 or (230 V must be specified) ±10%, 48 to 440 Hz; 80 VA max.	
Dimensions:	cabinet mount: 7½" wide, 11½" high, 12" deep (191 x 292 x 305 mm) rack mount: 19" wide, 7" high, 10⅞" deep behind panel (483 x 389 x 276 mm)	
Weight:	net 18 lbs (8.1 kg), shipping 20 lbs (9,0 kg) (cabinet mount); net 21 lbs (9,45 kg), shipping 32 lbs (14.4 kg) (rack mount)	
Price:	HP 400D, cabinet, $385 HP 400DR, rack mount, $390 Option 001, dB scale uppermost, add $25.	HP 400H, cabinet, $395 HP 400HR, rack mount, $400 Option 001, dB scale uppermost, add $25.

AC VOLTMETERS
10 Hz to 10 MHz, 100 μV to 1 kV
Models 400E, EL, F, FL, GL



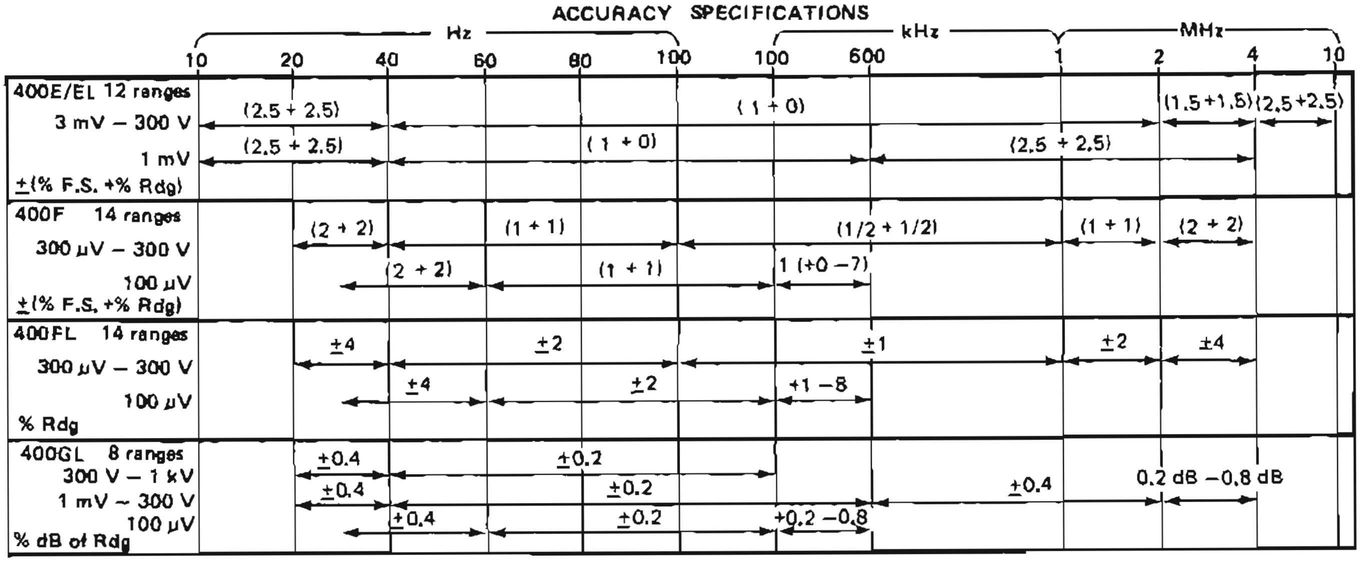
400E 400FL 400GL

Specifications

	400E	400F	400GL
Voltage Range	1 mV to 300 V F.S. 12 ranges	100 μV to 300 V F.S. 14 ranges	100 μV to 1 kV F.S. 8 ranges
Frequency Range	10 Hz to 10 MHz	20 Hz - 4 MHz	20 Hz - 4 MHz
Input Impedance	10 MΩ on all ranges <25 pF to <12 pF depending on ranges	10 MΩ on all ranges <25 pF to <10 pF depending on ranges	10 MΩ on all ranges <30 pF to <15 pF depending on ranges
Recovery	<2 s for 80 dB overload		
Overload	300 V max. input		1200 V max. input
Calibration	Scale −10 to +2 dB, 10 dB between ranges, 100 divisions on 0 to 1 scale		linear dB scale, 100 divisions from −20 to 0 dB. Log voltage scale 0 dB = 1 V
Weight	Net 6 lbs (2,7 kg); shipping 9 lbs (4,1 kg)		
Dimensions	5⅛" wide, 6¼" high (without removable feet), 11" deep (130 x 159 x 279 mm)		
Power	AC: 115 or 230 V ± 10%, 48 to 440 Hz, 6 VA max. DC: External Batteries: + and − voltages between 35 V and 55 V		
Price	$345 (400EL: $355)	$330 (400FL: $340)	$350

NOTE: 400EL same as 400E and 400FL same as 400F, except for calibration. Linear dB scale −10 dB to +2 dB. 10 dB between ranges. Log voltage scales 0.3 to 1 and 0.8 to 3, 120 divisions from −10 to +2 dB.

ACCURACY SPECIFICATIONS



RMS VOLTMETER
10 Hz to 10 MHz
Model 3400A

Description

The Hewlett-Packard Model 3400A is a true root-mean-square (rms) voltmeter, providing a meter indication proportional to the dc heating power of the input waveform. In addition to its meter indication, the Model 3400A provides a dc output proportional to meter deflection making it a useful true rms detector for graphic recording and digitizing with a dc digital voltmeter, such as the HP Model 3440A.

Versatility

Versatility of the Model 3400A is enhanced by its wide 10-Hz to 10-MHz frequency response, high crest factor, 1-mV to 300-Volt full-scale sensitivity and 10-MΩ input impedance. Six-decade frequency coverage makes the 3400A extremely flexible for all audio and most rf measurements and permits the measurement of broadband noise and fast-rise pulse. A wide range of sensitivity (12 ranges) allows measurement of anything from "down in the grass" signal and noise, to transmitter and amplifier outputs (with 30-dB overload protection). Pulses or other non-sinusoids with crest factors (ratio of peak to rms) up to 10:1 can be measured full scale. Crest factor is inversely proportional to meter deflection, permitting up to 100:1 crest factor at 10% of full scale. The ability of the 3400A to accept waveforms with such large crest factors insures accurate noise and pulse measurements without the need for correction factors. Permanent plots of measured data and higher resolution measurements can be obtained by connecting an X-Y plotter, strip chart recorder or digital voltmeter to the convenient rear-panel dc output. The dc output provides a linear 0 to 1-volt drive proportional to meter deflection.

RMS current

True-rms current measurements can be made conveniently by using the HP Model 456A Current Probe with the Model 3400A. See page 57.

Specifications

Voltage range: 1 mV to 300 V full scale, 12 ranges.

DB range: −72 to +52 dBm (0 dBm = 1 mW into 600Ω).

Frequency range: 10 Hz to 10 MHz.

Response: responds to rms value (heating value) of the input signal for all waveforms.

Meter accuracy: % of full scale (20°C to 30°C)*

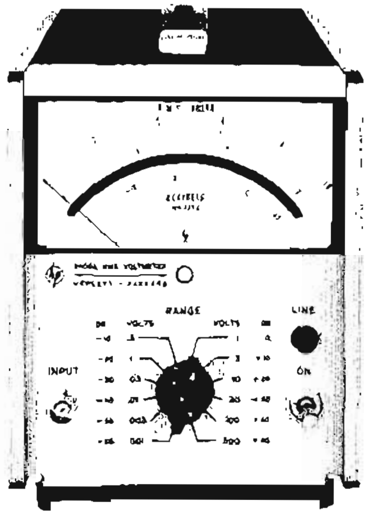
10 Hz – 50 Hz	50 Hz – 1 MHz	1 MHz – 2 MHz	2 MHz – 3 MHz	3 MHz – 10 MHz
±5%	±1%	±2%	±3%	±5%

Ac-to-dc converter accuracy: % of full scale (20°C to 30°C)*

10 Hz – 50 Hz	50 Hz – 1 MHz	1 MHz – 2 MHz	2 MHz – 3 MHz	3 MHz – 10 MHz
±5%	±0.75%	±2%	±3%	±5%

Crest factor: (ratio of peak to rms amplitude of input signal): 10 to 1 at full scale (except where limited by maximum input) inversely proportional to meter deflection, (e.g., 20 to 1 at half-scale, 100 to 1 at tenth scale).

*TC: ±0.1% from 0°C to 20°C and 30°C to 55°C.



3400A

Maximum continuous input voltage: 500 V ac peak at 1 kHz on all ranges; 600 V dc on all ranges.

Input impedance: from 0.001 V to 0.3 V range: 10 MΩ shunted by <50 pF. From 1.0 V to 300 V range: 10 MΩ shunted by <20 pF, ac-coupled input.

Response time: for a step function, <5 s to final value.

AC overload: 30 dB above full scale or 800 V p, whichever is less, on each range.

Output: negative 1 V dc into open circuit at full-scale deflection, proportional to meter deflection from 10-100% of full scale. 1 mA maximum; nominal source impedance is 1000Ω. Output noise <1 mV rms.

Power: 115 or 230 V ±10%, 48 to 440 Hz, 12 VA max.

Dimensions: 5⅛" wide, 6¼" high (without removable feet), 11" deep (⅓ module). (130 x 159 x 279 mm).

Weight: net: 7¼ lbs (3,3 kg); shipping: 10 lbs (4,5 kg).

Accessories furnished: 10110A Adapter, BNC to dual banana jack.

Accessories available: 11001A Cable, 45 in. long, male BNC to dual banana plug, $13.00 10503A Cable, 4 ft. long, male BNC connectors, $13.00. 11002A Test Lead, dual banana plug to alligator clips, $10.00. 11003A Test Leads, dual banana plug to probe and alligator clip, $10. 11076A Carrying Case, $60. HP Model 456A AC Current Probe, 1 mV/1 mA, $300.

Price: HP 3400A, $600.

HP Model 3400A option 001 spreads out the dB scale by making it the top scale of the meter, add $25.

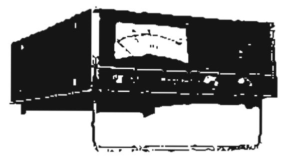
Rear terminals in parallel with front panel terminals and linear log scale uppermost on the meter face are available on special order.

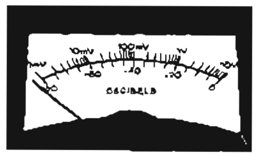
LOGARITHMIC VOLTMETERS

Convert ac or dc signals to logarithmic scaling

Models 7562A and 7563A

Log Voltmeter/Converter Model 7562A





The Model 7562A is a wide range (80 dB), single channel logarithmic voltmeter/converter designed to produce dc output voltages in a logarithmic relationship to dc input voltages or the true RMS value of an ac input voltage. The 7562A contains a true RMS detector which, inherently, is not dependent on pure sinusoidal signals to achieve measurement accuracy. A self-contained meter calibrated in volts and dB makes the 7562A an accurate voltmeter. A constant amplitude oscilloscope output makes the converter compatible with a variety of oscilloscope readout and phase meter applications.

Specifications

Performance specifications

Ac and dc modes

Input:

Dynamic range: 80 dB.

Voltage range: 1 mV to 10 V or 10 mV to 100 V selectable by front panel switch. Accepts either ac or positive signals.

Output:

Voltage: 0 to 800 mV dc corresponding to 10 mV/dB.

Output impedance: 100 ohms.

Dc mode

Accuracy: ±0.25 dB at 25°C.

Input impedance: 100 kΩ, shunted by less than 100 pF; single ended.

Temperature coefficient: ±0.02 dB/°C maximum.

Zero stability: ±0.25 dB.

Ac mode

Input impedance: 1 MΩ, shunted by less than 100 pF; single ended.

Accuracy and frequency response: (at 25°C).

RANGE SETTING	0.5Hz–2	2–5	5–20	20–50	50–200Hz	200Hz–50KHz	50KHz–100KHz
0.5Hz	±1dB	±0.5dB					±1 dB
5Hz			±1dB	±0.5dB			±1 dB
50Hz					±1dB	±0.5dB	±1 dB

Temperature coefficient: ±0.04 dB/°C maximum.

Slewing speed:

Range setting	Minimum slewing speed
0.5 Hz	1 dB/s
5 Hz	10 dB/s
50 Hz	60 dB/s

Oscilloscope output: approx. 0.5 V rms regardless of input.

Crest factor: 5:1 unless limited by max. input voltage.

General specifications

Maximum peak input voltage: ±25 V on 1 mV to 10 V range; ±250 V on 10 mV to 100 V range.

Operating temperature: 10°C to 40°C.

Warm-up time: 20 minutes nominal.

Connectors: front and rear-input and output-BNC connectors.

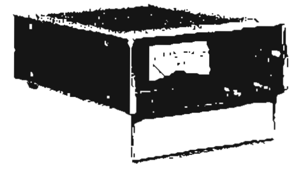
Power requirements: 115/230 Vac, 50 to 400 Hz, 40 VA.

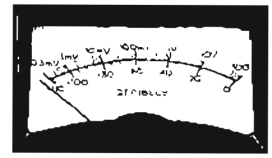
Dimensions: 3-7/16" high, 7¾" wide, 11½" deep (88 x 197 x 292 mm).

Weight: net, 8 lb (3,6 kg); shipping, 12 lb (5,4 kg).

Price: Model 7562A $1095.

Log Voltmeter/Amplifier Model 7563A





The Model 7563A Logarithmic Voltmeter/Amplifier is a low cost, single channel, dc logarithmic amplifier with a very high dynamic range (110 dB) designed to produce a logarithmic-related dc output voltage for a very wide range of dc input voltages. A single input range of 316 µV to 100 V is coupled with an input polarity switch for ease and versatility of operation. A high (100 kΩ) input impedance and low (less than 5Ω) output impedance allows the 7563A to be used in systems or on the bench. A front panel meter calibrated in dB and mV provides instantaneous visual indication of operating levels. Applications include: log scaling of recorder axes, pulse height analyzers, scope displays, and almost any circumstance where log compression of dc voltage ranges is required. The 7563A is an accurate voltmeter. Dual or single rack mounting capability is afforded by a field installable rack mounting adapter, utilizing a minimum of rack space.

Specifications

Performance specifications

Input

Dynamic range: 110 dB.

Voltage range: 316 µV to 100 V. Accepts either positive or negative signals, selectable by front panel switch.

Output

Voltage: 0 to 1.1 V dc corresponding to 10 mV/db. Rear Terminals; adjustable 1 to 10 mv/dB.

Output impedance: less than 5Ω front panel, 300Ω rear.

Meter accuracy: reading accurate to ±1.5 dB, referred to output.

Input impedance: 100 kΩ, shunted by less than 100 pF; single ended.

Accuracy: (at 25°C).

316 µV – 1 mV	1 mV – 10 V	10 V – 31.6 V	31.6 V – 100 V
±0.5 dB	±0.25 dB	±1.0 dB	±1.5 dB

Temperature coefficient: ±0.02 dB/°C maximum and ±3 µV/°C referred to input.

Zero stability: ±0.25 dB at constant temperature.

Rise time:

Maximum Rise Time	
Signal Level	**1 mV–10 V Range**
316 µV– 1 mV	2000 µs
1 mV– 10 mV	400 µs
10 mV–100 mV	40 µs
100 mV– 1 V	4 µs
1V–100 V	2 µs

General specifications

Operating temperature: 10°C to 40°C.

Warm-up time: 20 minutes nominal.

Connectors: front and rear-input and output-BNC connectors.

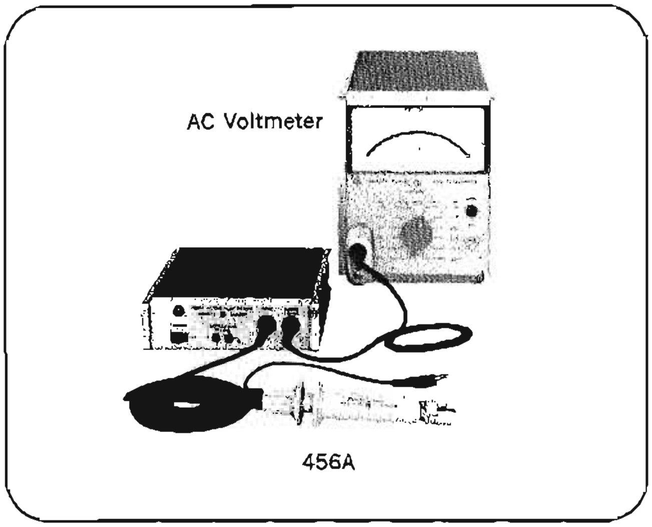
Power requirements: 115/230 V ac, 50 to 400 Hz, 40 VA.

Dimensions: 3-7/16" high, 7¾" wide, 11½" deep (88 x 197 x 292 mm).

Weight: net, 8 lb (3,6 kg); shipping, 12 lb (5.4 kg).

Price: Model 7563A $795.

VOLTMETER ACCESSORIES
Voltage dividers, current probe for VM's
Model 456A, 11000 Series

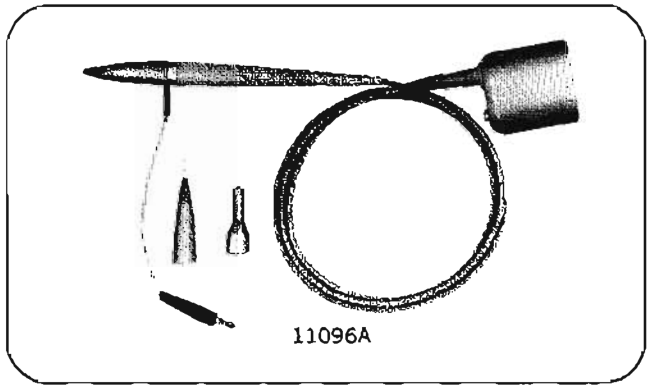


456A AC Current Probe

The conventional voltmeter or oscilloscope can measure current quickly and dependably—without direct connection to the circuit under test or any appreciable loading to the test circuit. The HP 456A AC Current Probe clamps around the current-carrying wire and provides a voltage output you can read on a voltmeter or scope. Model 456A's 1 mA to 1 mV conversion permits direct reading up to one ampere rms.

Specifications, 456A

Sensitivity: 1 mV/mA ±1% at 1 kHz.
Frequency response: ±2%, 100 Hz to 3 MHz; ±5%, 60 Hz to 4 MHz; −3 dB at <25 Hz and >20 MHz.
Pulse response: rise time is <20 ns, sag <16%/ms.
Maximum input: 1 A rms, 1.5 A p; 100 mA above 5 MHz.
Effect of dc current: no appreciable effect on sensitivity and distortion from dc current up to 0.5 A.
Input impedance: (impedance added in series with measured wire by probe) <50 mΩ in series with 0.05 μH (this is approximately the inductance of 1½" of hookup wire).
Probe shunt capacity: approx. 4 pF added from wire to ground.
Distortion at 1 kHz: for 0.5 A input at least 50 dB down; for 10 mA input at least 70 dB down.
Equivalent input noise: <50 μA rms (100 μA when ac powered).
Output impedance: 220Ω at 1 kHz; approximately +1 V dc component; should work into load of not less than 100,000Ω shunted by approximately 25 pF.
Power: two Mallory TR 233R and one TR 234 batteries (1420-0005 and 1420-0006); battery life approximately 400 hrs; ac power supply optional, 115 or (230 V must be specified) ±10%, 50 to 400 Hz, 1 W.
Dimensions: 5" wide, 1½" high, 6" deep (127 x 38 x 152 mm); probe cable is 5' long; 2' output cable terminated with dual banana plug. Probe aperture: 5/32" (4 mm) diameter.
Weight: net, 2 lbs 4 oz (1 kg); shipping, 3 lbs 10 oz (1,6 kg).
Accessory available: 456A-11A AC Supply for field installation; 11028A 100:1 Current Divider, $60.
Price: HP 456A with batteries, $300.
Option 001: ac supply installed in lieu of batteries, add $20.



11096A High Frequency Probe

Converts dc voltmeter with 10 MΩ input resistance to high frequency ac voltmeter. Compatible voltmeters: HP 427A, HP 3469B, HP 3470A, and HP 3440A. Voltage range, 0.25 to 30 V rms; transfer accuracy (20-30°C) ±5%, 100 kHz to 100 MHz. Usable for relative measurements from 1 kHz to 1 GHz; peak responding, calibrated to read rms value of a sine wave; input impedance, 4 MΩ shunted by 2 pF; max. input, 30 V rms ac, 200 V dc; accessories provided include a straight tip, a hook tip, a ground clip, and a high frequency adapter that fits available HP adapters for BNC (HP 10218A); GR Type 874 (HP 10219A), Microdot connectors (HP 10220A) and that also fits a 50Ω tee (HP 11536A). Price: HP 11096A, $75.

11074A Voltage Divider Probe

For 400 series voltmeters. Provides low-input capacitance and high-input resistance at the point of measurement. Division ratio 10:1 ±2% (400 Hz reference), 10:1 ±2% (100 kHz reference depends on adjustment of compensating capacitor). Bandwidth, dc to 10 MHz. Maximum input voltage 1 kV rms.

Input impedance: 10 MΩ shunted by 10 pF (when connected to an input impedance of 10 MΩ shunted by not more than 25 pF). Price: HP 11074A, $75.

11043A Probe Coaxial "N" Connector

For 410 series voltmeters. Measures at open end of 50Ω transmission line (no terminating resistor). Has male Type N fittings. Price: HP 11043A, $45.

11045A DC Voltage Divider

For 410C Voltmeter. Gives maximum safety and convenience for measuring high voltages as in television receivers, etc. Accuracy, ±5%; division ratio, 100:1. Input impedance, 10 GΩ. Maximum voltage, 30 kV. Max current drain, 2.5 μA. HP 11045A, $60.

11042A Probe Coaxial "T" Connector

For 410 series voltmeters. Measures voltages between center conductor and sheath of 50Ω transmission line. Maximum SWR, 1.1 at 500 MHz, 1.2 at 1 GHz. Male and female Type N fittings. Price: HP 11042A, $60.

IMPEDANCE METERS — LOW AND MEDIUM FREQUENCIES

Impedance/Z/θ,C,R,L, D&Q

Hewlett-Packard's family of impedance measurement instruments combine the familiar null measurement techniques with digital logic and feedback circuits, to achieve simple and rapid operation without a sacrifice in precision. The basic specifications for Hewlett-Packard's impedance family is summarized in table 1. Frequency, Q, capacitance, inductance, resistance and basic accuracy can be traded off to select the most suitable instrument. For some instruments, capacitance and inductance are not the principal parameters but are secondary to the primary readout.

Impedance considerations

There are two basic types of impedance measuring instruments: bridge instruments and meters. In general, bridge type instruments have the best accuracy specifications. This type of instrument has found wide application and is the basis for the HP 4260A/4265A Universal Bridge, 4270A Automatic Capacitance Bridge, and 250B RX Meter.

In the past, bridge instruments have required considerable operator skill to obtain consistent results. However, the Universal Bridge was specifically designed to achieve rapid and consistent audio frequency measurements.

The evolution of bridge measurements has created the need for completely automatic instruments to rapidly characterize multi-conductor cables, variable capacitor diodes, and discrete capacitors. To satisfy these customer requirements, the 4270A Automatic Capacitance Bridge was developed. This instrument is completely programmable and displays capacitance and dissipation/conductance in digital form. BCD outputs are available for remote processing.

Impedance meters, in general, utilize constance current/voltage sources to excite the unknown impedance. Amplitude and phase sensitive voltmeters detect the real and reactive voltage/current components of the unknown. The display for most impedance meters is an analog meter. Although impedance meters do not have the accuracy of bridge instruments, they are less expensive and very easy to use. The 4350A High Capacitance Meter, 4800A Vector Impedance Meter, and the 4332A LCR Meter utilize this principal. Impedance meters have analog outputs proportional to the displayed function. This signal may be used with the 4050A Analog Comparator to select components on a High/Go/Low basis.

The new 4271A LCR Meter utilizes a combination of bridge and digital voltmeter techniques, to enable it to measure micro-circuit parameters.

Summary

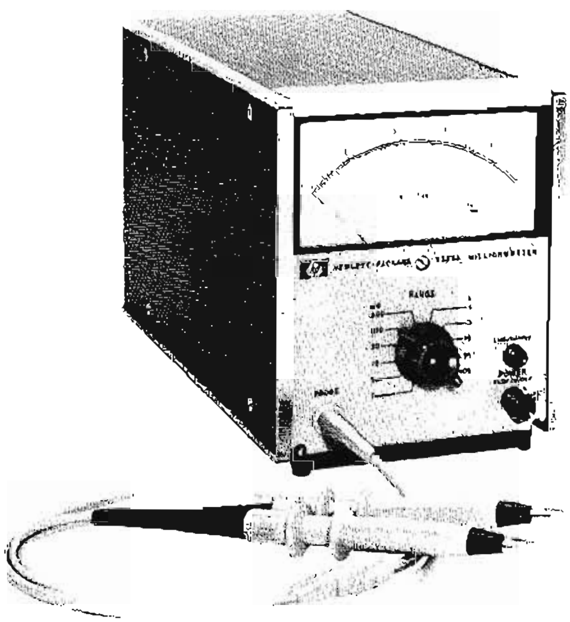
To help you select an impedance meter suitable to your needs, the following guidelines may be used:

(1) For a desired accuracy and cost range, select the instrument with the broadest capability in C, L, R & Q. (2) Bridge instruments will provide the best accuracies (.1% to 1%). However, only the higher priced bridges offer the speed and convenience in measurement available in meter type instruments. (3) The best value, where parts selection is desired, is a meter instrument where an analog signal is available for use with an analog comparator. (4) To obtain meaningful results, a parts user should make measurements at the same frequency specified by the manufacturer. (5) Hewlett-Packard's impedance instruments have been used in numerous diverse applications, from the measurement of the dielectric constant of liquids, to the wing to fuselage continuity on aircraft. If you have an unusual application or need assistance, contact your nearest Hewlett-Packard sales office for application information.

TABLE 1. HP IMPEDANCE METERS

Instrument	Frequency (DC, 1 Hz, 1 kHz, 1 MHz, 1 GHz)	Q or 1/D (10^0, 10^{+3})	C in farads, L in henries or R in ohms (10^{-12}, 10^{-6}, 10^0, 10^{+3})	Basic Accuracy (.1%, 1%, 10%)	See Page
RX Meter 250B			C, L	•	64
Universal Bridge 4260A			C, R, 10^6, L	•	61
Universal Bridge 4265A			C, R, 10^6, L	•	62
Auto C-Bridge 4270A			C	•	63
1 MHz LCR Meter 4271A			C, L, R, 10^5	•	65
Milliohm Meter 4328A			R	•	59
High Resistance Meter 4329A			10^6, R, 10^{16}	•	60
LCR Meter 4332A			C, L, R, 10^6	•	66
Q Meter 4342A			C, L	•	68
High C Meter 4350A/B			C	•	66
Vector /Z/ Meter 4800A			C, L	•	66

MILLIOHMMETER
Convenient two probe measurements
Model 4328A



4328A

Description

The HP 4328A Milliohmmeter is a portable instrument for measurement of low resistances. It uses a Kelvin Bridge method to obtain its high sensitivity but has incorporated both the current and voltage drives into one probe, so that only two probes are needed in the actual measurement.

The range of the 4328A extends from 100 ohms to one milliohm full scale. Maximum sensitivity is 20 microhms, making it ideal for measuring the contact resistance of switches, relays, and connectors.

A unique phase discriminator in the meter circuit permits accurate resistive measurements on samples with a series reactance up to twice full scale resistance.

The milliohmmeter is internally driven by a one kilohertz signal. With an ac drive signal, dc bias up to 150 volts can be superimposed without affecting the accuracy of the measurement. Hence, the 4328A can make dynamic resistance measurements in back-biased diodes.

Maximum voltage across any sample with the proper range selection is less than 200 microvolts peak. In case of incorrect range setting, a maximum voltage of 20 millivolts peak will never be exceeded, so that explosive devices such as fuses and squibs can be safely checked.

The basic 4328A is line operated. With Option 001, it can be operated from four rechargeable batteries for 15 continuous hours. A recorder output provides an output proportional to the meter deflection.

Specifications

Range: 0.001 to 100 ohms full scale in a 1, 3, 10 sequence.

Accuracy: ±2% of full scale. No additional error is caused by series reactance of samples up to two times full scale.

Measuring frequency: 1000 Hz ±100 Hz.

Voltage across sample: 200 μV peak at full scale.

Maximum voltage across sample: 20 mV peak in any case.

Superimposed dc: 150 V dc maximum may be superimposed on samples from an external source.

Recorder output: 0.1 V dc output at full scale meter deflection.

Range (ohms)	Applied Current (mA)	Maximum Dissipation in Samples (μW)
0.001	150	23
0.003	50	8
0.01	15	2.3
0.03	5	0.8
0.1	1.5	0.23
0.3	0.5	0.08
1	0.15	0.023
3	0.05	0.008
10	0.015	0.0023
30	0.005	0.0008
100	0.0015	0.00023

General

Power requirements: 115/230 V switch ±10%, 50 to 60 Hz, 1.5 W.

Weight: 7 lbs (3,2 kg).

Dimensions: 5⅛" wide, 6-3/32" high, 11" deep.

Accessories furnished: Model 16005A Probe, 16006A Probe and 16007A Test Leads. Detachable Power Cord.

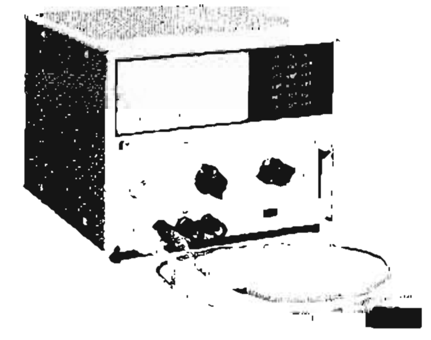
Price: HP 4328A, $620.

Option 001: rechargeable battery operation, add $33.

RESISTANCE METER

Wide range for high resistance, low current

Model 4329A



4329A

Description

The HP 4329A is a solid-state insulation resistance meter designed for easy, accurate and direct readings of the very high resistance values typically found in synthetic resins, porcelain, insulating oils and similar materials. It is also useful for measurements in electrical components like capacitors, transformers, switches and cables. Seven fully regulated dc test voltages (between 10 and 1000 V) are provided as test sources.

Selected scales are identified by illuminated indicators on the meter face. Selected resistance or current multiplying factors are also illuminated for rapid, error-free measurement. Three resistance scales and one current scale are provided. The HP 4329A is instantly convertible from ungrounded- to grounded-sample operation via a simple relocation of the front panel ground strap from "guard" to "+" position. The instrument cabinet itself is always at ground potential. Test voltage shorts or sample breakdown currents will not damage instrument circuitry.

The HP 4329A also has a current measurement capability. Minute currents as low as 0.05 pA can be readily measured. The standard instrument package includes HP 16117A Low Noise Test Leads; these are used in most types of measurement. An HP 16008A resistivity cell is also available for use with the high resistance meter, for those customers engaged in measurement of volume and surface resistivity of sheet samples.

Specifications

Resistance measurement:

Range: 500 kΩ to 2×10^{16}Ω.

Test voltage	10 V	25 V	50 V	100 V	250 V	500 V	1000 V
Available resistance readings	5×10^5Ω to 2×10^{14}Ω	1.25×10^6Ω to 5×10^{14}Ω	2.5×10^6Ω to 1×10^{15}Ω	5×10^6Ω to 2×10^{15}Ω	1.25×10^7Ω to 5×10^{15}Ω	2.5×10^7Ω to 1×10^{16}Ω	5×10^7Ω to 2×10^{16}Ω
Meter scale	.5 to 20	.13 to 5	.25 to 10	.5 to 20	.13 to 5	.25 to 10	.5 to 20
Upper limit	5	1.25	2.5	5	1.25	2.5	5

Accuracy: total accuracy is determined by test voltage and range used. At low resistance end of each scale accuracy is ±3%; near center scale ±5%, and near the specified upper limit on the meter scale (see table above) accuracy is ±10%. Above these limits accuracy is not specified. On all voltage ranges, if multiplier is set to Rmax., an additional ±3% is included.

Current measurement

Range: 0.5×10^{-13} to 2×10^{-16} A in 8 ranges.

Meter scale: 0 to 20 in 40 linear divisions.

Input resistance: 10^4 to 10^{11}Ω ±1%, depending on range.

Accuracy: ±5% of full scale deflection (there can be an additional ±3% error at the top decade).

General

Recorder output: 0 to 100 mV dc, proportional to meter deflection; 1 kΩ output resistance.

Power: 114/230 V ±10%, 50-60 Hz, 3 W.

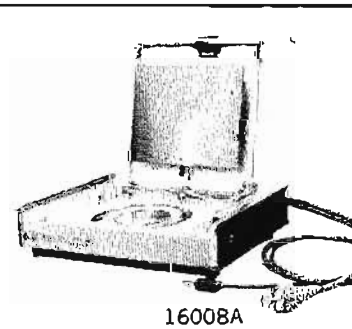
Dimensions: 6½" high (166 mm), 7-25/32" wide (198 mm), 8-25/32" deep (223 mm).

Weight: 8 lbs (3,5 kg).

Accessory furnished: HP 16117A Low Noise Test Leads.

Price: HP 4329A, $840.

Model 16008A Resistivity Cell



16008A

Description

The HP 16008A can safely, rapidly and conveniently measure the volume and surface resistivity of sheet insulation materials. Conversion from volume to surface resistivity measurement requires operation of one switch only; no lead interchange or disconnection is necessary. Designed for use with the HP 4329A Resistance Meter (other voltage supplies and picoammeters may be used), the complete system allows direct measurement of volume resistivity up to approximately 4×10^{15}Ω (on samples 0.1 cm thick)—and surface resistivity up to approximately 4×10^{17}Ω. Test voltages up to 1000 V may be used. Excellent sample-to-electrode contact is maintained through use of a conducting plastic layer bonded to the inner electrode's outer surface. An interlock switch automatically disconnects the test voltage when the cover is raised. Convenient low noise test leads are supplied for direct connection to the HP 4329A.

Specifications

Inner electrode: 50 mm∅.

Guard electrode: 70 mm∅.

Auxiliary electrode: 100 x 120 mm.

Maximum sample size: 125 x 125 x 7 mm.

Maximum test voltage: 1000 V dc.

Dimensions: 2" high (49 mm), 7-13/16" wide (198 mm), 6⅛" deep (156 mm).

Weight: 3 lbs (1,4 kg).

Price: HP 16008A, $280.

UNIVERSAL BRIDGE
Simplified, easy to read impedance measurement
Model 4260A

Advantages:

Electronic AUTOBALANCE — single control null
Digital Readout for C, R, L
Direction Indicators for fast range selection and balance

Measurements of C, R, L, D (dissipation factor of capacitors), and Q are easily made with the new Model 4260A Universal Impedance Bridge.

The readout for C, R and L is digital with the decimal point automatically positioned. Units of measurement and the equivalent circuit automatically appear with a twist of the function switch. There are no multipliers or confusing non-linear dials which need interpolation.

Operation is simple. Set the function knob for the parameter to be measured, adjust the range switch for an on-scale indication, and obtain a null with the CRL control. There are no interacting controls to adjust and readjust. There are no false nulls. A unique electronic AUTOBALANCE circuit solves all these problems. Components with low Q or high Q are as easy to measure as those without loss.

For D or Q measurements, switch out of AUTO and turn the DQ control until another null is obtained. Only one adjustment is needed for each measurement.

Five bridge circuits are incorporated in the 4260A; each is composed of stable, high-quality components for good accuracy and linearity. An internal 1 kHz drives the bridge.

Nulling is easy. Illuminated pointers (< CRL >) automatically tell whether a null is up- or down-scale. Both range and CRL controls can be set watching these pointers.

Components may be biased by connecting a battery to the rear terminals. An external oscillator and detector can be used for measurements in the 20 Hz - 20 kHz range.

The compact modular cabinet is ideal for bench use; and it may be rack mounted using accessory hardware. A tilt stand is provided to raise the viewing angle; it also serves as a convenient carrying handle.

Specifications

Capacitance measurement

Capacitance
Range: 1000 pF to 1000 μF, in 7 full scale ranges.
Accuracy:
± (1% + 1 digit), from 1 nF to 100 μF.
± (2% + 1 digit), from 1 pF to 1 nF and 100 μF. to 1000 μF.

Dissipation factor
Range:
LOW D—(of series C): 0.001 to 0.12.
HIGH D—(of parallel C): 0.05 to 50.
Accuracy: for C >100 pF.

LOW D .... $\pm \dfrac{2}{\sqrt{\text{D of Reading}}}$ %.

HIGH D .... $+$ (10 D of Reading + 4) %.
$-$ (10 $\sqrt{\text{D of Reading}}$ + 2) %.

Add ±1 dial division for frequencies other than 1 kHz.

Inductance measurement

Inductance
Range: 1000 μH to 1000 H, in 7 full scale ranges.
Accuracy:
±(1% + 1 Digit), from 1 mH to 100 H.
±(2% + 1 Digit), from 1 μH to 1 mH and 100 H to 1000 H.

4260A

Quality factor
Range:
LOW Q—(of series L): 0.02 to 20.
HIGH Q—(of parallel L): 8 to 1000.
Accuracy: for L >100 μH.

LOW Q .... $+ \left(\dfrac{10}{\text{Q of Reading}} + 4\right)$ %.
$- \left(\dfrac{10}{\sqrt{\text{Q of Reading}}} + 2\right)$ %.

HIGH Q .... $\pm\ 2\sqrt{\text{Q of Reading}}$ %.

Add ±1 dial division for frequencies other than 1 kHz.

Auto-balance

Eliminates need for DQ adjustments in parallel C and series L measurements at 1 kHz.
Accuracy: for D <1 and Q >1 add ±0.5% to C and L accuracy specifications.

Resistance measurement

Range: 10Ω to 10 MΩ, in 7 full scale ranges.
Accuracy:
10 mΩ to 10Ω ±(2% +1 digit).
10Ω to 1 MΩ ±(1% +1 digit).
1 MΩ to 10 MΩ ±(2% +1 digit).
To obtain better sensitivity use HP 4304B below 100Ω and above 100 kΩ.

Oscillator and detector

Internal oscillator: 1 kHz ± 2%. 100 mV rms ± 20%.
Internal detector: tuned amplifier at 1 kHz; functions as a broadband amplifier for measurements with external oscillator.

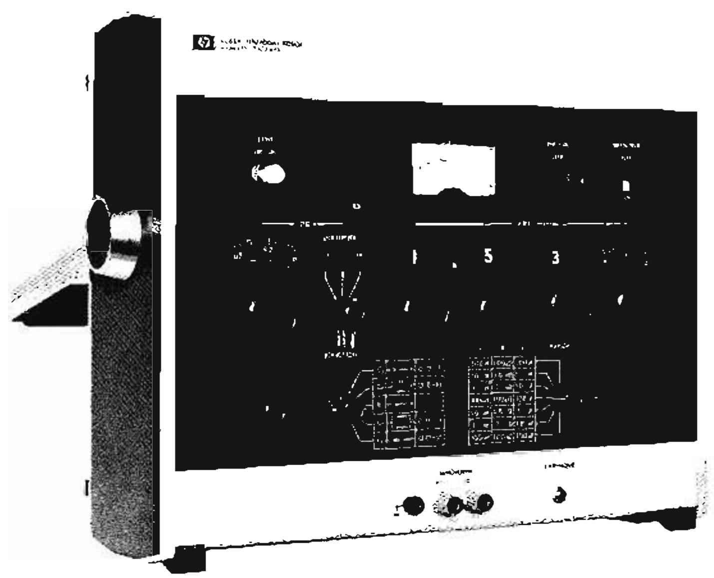
General

Power: 115 or 230 volts ± 10%, 50-60 Hz, approx. 7 watts.
Dimensions: 7-25/32" wide, 6-17/32" high, 11" deep (190 x 166 x 279 mm).
Weight: net, 11 lbs (5 kg); shipping, 15 lbs (6,8 kg).
Optional accessories:
HP 4304B for R measurements <100Ω and >100 kΩ.
HP 204C Opt. 001 for measurements 20 Hz-20 kHz.
HP 140A/1400A or external tuned null detector with 90 dB gain and Z_{in} >10 kΩ for measurements 20 Hz-20 kHz.
Price: Model 4260A Universal Bridge, $680.

UNIVERSAL BRIDGE

Measures .1 μH-1111H, .1 pF-1111 μF, .1 m Ω-1 MΩ

Model 4265A



NEW▶
4265A

Description

The new Hewlett-Packard Model 4265A Universal Bridge provides an economical way to make high precision measurements of L, C, or R and D or Q. Components can be measured in the ranges of 0.1 μH to 1111 H in inductance, 0.1 pF to 1111 μF in capacitance and 0.1 mΩ to 1.111 MΩ in resistance with full four digit in-line display. The L and C measurements are performed over a wide range of loss with either series or parallel equivalent circuits selected by the FUNCTION switch. The basic measurement accuracy is 0.2% of reading for L, C and R.

The measurement frequency range is 50 Hz to 10 kHz with an external oscillator, and 1 kHz with internal oscillator. A dc measurement for resistance is also available with external dc power supply and null detector.

The front panel design provides appropriate space and convenient positioning of knobs for easy balancing. The rugged handle is used as the tilt stand, and a front panel angles of 40 or 60 degrees may be chosen.

Specifications

Resistance measurement

Full scale range: 1111.0 mΩ to 1.1110 MΩ, 7 ranges.

Minimum resolution: 0.01 mΩ by minor division of the lowest digit.

Accuracy: at 1 kHz.
±(0.2% of reading +0.01% of F.S. +0.2% of reading on lowest range).

Residual resistance: ≈ 3 mΩ.

Inductance measurement

Full scale range: 1111.0 μH to 1111 0 H, 7 ranges.

Minimum resolution: 0.01 μH by minor division of the lowest digit.

Accuracy: at 1 kHz.
±(0.2% of reading +0.01% of F.S. +0.2% of reading on lowest range).

Residual inductance: ≈ 0.2 μH.

Loss factor range: (at 1 kHz).
Q of series L: 0 to 10, accuracy ±(5% of reading +0.001).
D of parallel L: 0.001 to 1, accuracy ±(5% of reading +0.001).

Capacitance measurement

Full scale range: 1111.0 pF to 1111.0 μF, 7 ranges.

Minimum resolution: 0.01 pF by minor division of the lowest digit.

Accuracy: at 1 kHz.
±(0.2% of reading +0.01% of F.S. +0.2% of reading on lowest range).

Residual capacitance: ≈ 0.4 pF.

Loss factor range: (at 1 kHz).
D of series C: 0.001 to 1, accuracy ±(5% of reading +0.001).
Q of parallel C: 0 to 10, accuracy ±(5% of reading +0.001).

Oscillator

Internal oscillator
Frequency: 1 kHz ±15 Hz.
Output: continuously variable with front panel control. Maximum voltage is approximately 0.3 V rms.

External oscillator
Frequency range: 50 Hz to 10 kHz or dc for resistance measurement.
DC bias: 250 V max in Cs mode from external source.

Internal detector
Tuned amplifier at 1 kHz.
Minimum sensitivity 10 μV, selectivity more than 26 dB down at 2nd harmonics. May also be used as a broad-band amplifier from 50 Hz to 10 kHz for measurement with external oscillator.

General

Power: 100/120/200/240 V ±10%; 48 to 440 Hz, 5 W.

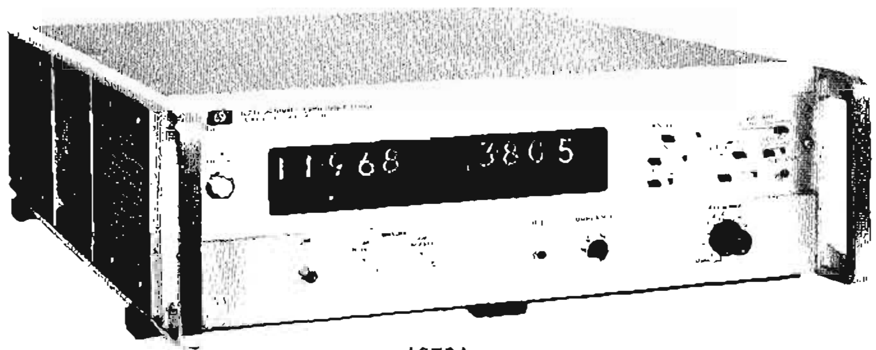
Accessories available
Model 16029A Test Fixture.
Model 4403A Tuned Null Detector.

Prices: Available Spring 1973.

CAPACITANCE BRIDGE

Fully automatic, 1 kHz to 1 MHz

Model 4270A



4270A

Description

A unique instrument from Hewlett-Packard, the 4270A Automatic Capacitance Bridge provides a wide variety of high speed measurements of both active and passive capacity values. Five-digit readout of capacitance from full-scale ranges of 18.000 pF to 1.2000 μF is complemented by .001 pF resolution and measurement speed of 0.5 seconds. In addition, a second in-line 4-digit Nixie® display of capacitor loss is given simultaneously in terms of parallel conductance (G) or dissipation factor (D). In the laboratory, the 4270A will be extremely useful for examination of semiconductor junction capacities, input capacitances of amplifiers and other active devices, as well as the analysis of stray capacity values, cables and simple capacitors. DC biasing, four frequencies from 1 kHz to 1 MHz and a fully guarded measurement will add to laboratory flexibility.

Specifications

Measuring circuit

Float: guarded terminals of unknown are floated from ground.

L-ground: one side of known terminals is grounded, guard is retained.

Parameters measured: capacitance, equivalent parallel conductance and dissipation factor.

Measuring frequency: 1 kHz, 10 kHz, 100 kHz and 1 MHz.

Range modes

Auto: range selection and balance performed automatically.

Hold: range is held on fixed position, balance begins with most significant digit. Range determined by previous AUTO or TRACK range selected or by manually stepping RANGE STEP.

Track: range held on fixed position, balance begins with last digit.

Balancing time: typically 0.5 s.

Measuring rate: measurement cycle equals balance time plus display time. Balance time typically 0.5 s; display times selected by MEAS RATE are 70 ms, 2 secs, 5 secs and MANUAL.

Test voltage across unknown

Normal: 1 V rms constant, at capacitance units displayed in pF or nF; 100 mV rms constant at μF.

Low: 200 mV rms constant at pF or nF. 20 mV rms constant at μF.

Repeatability: ±2 digits at NORMAL TEST VOLTAGE, ±10 digits at LOW TEST VOLTAGE.

DC bias: INTERNAL or EXTERNAL to ±200 V, in HOLD and TRACK mode.

Internal bias at float measurement

Voltage: 0 to 20 V dc; 0 to 200 V dc; continuously variable on front panel, monitored on rear panel.

Dial accuracy: ±5% of full scale.

Source resistance: 100 kΩ.

Polarity: LOW unknown terminal (−), HIGH unknown terminal (+) in FLOAT position of MEAS CKT control.

Remote: programmable by resistor with 250 Ω/V rate at 20 V range, 25 Ω/V rate at 200 V range.

Remote accuracy: ±2% of full scale.

Internal bias at L-ground: an additional connection using a blocking capacitor and a coaxial cable is necessary for INTERNAL source.

Basic accuracy

	Frequency	1 kHz & 10 kHz	100 kHz	1 MHz
C	Basic Accuracy D< .1	±.1% ±1 digit ±.01 pF	±.3% ±1 digit ±.01 pF	±1% ±1 digit ±.01 pF
	Basic Accuracy .1 <D <1	±.2% ±1 digit ±.01 pF	±.5% ±1 digit ±.01 pF	±2% ±1 digit ±.01 pF
G	Basic accuracy	±1% ±10 digits	±3% ±10 digits	
D	Basic accuracy	±1% ±(10 +Cs/Cx) digits	±3% ±(10 + Cs/Cx) digits	

Outputs: 4 line BCD.

Inputs

Trigger hold off level: level must be between 10 V and 15 V.

Remote programming: eight front-panel functions can be remotely controlled by external contact closure to ground with impedance less than 400Ω. Programmable functions are RESET, FREQUENCY, RANGE MODE, TEST VOLTAGE, LOSS MEAS, RANGE STEP, DC BIAS, BIAS VERNIER.

Operating temperature: 0°C to 50°C.

Power requirements: 115 or 230 V ac ±10%, 50 to 60 Hz.

Weight: net, 34 lb (15,5 kg); shipping, 48 lb (21,6 kg).

Price: HP 4270A, $4640.

Interface kit

Interface kits 16150A Control Card and 16151A Data Card are available for interface with Hewlett-Packard computers. Each kit includes mating cable, BCS HP 4270A driver and diagnostic tape.

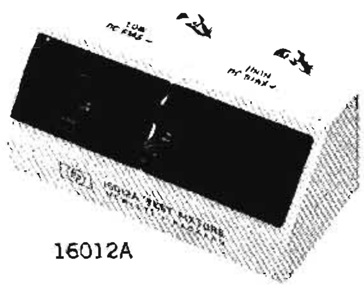
Price: HP 16150A, $1110; 16151A, $1455.

Accessories for the 4270A Automatic Capacitance Bridge

The following adapters convert the BNC Connectors on the 4270A to allow direct insertion of components.

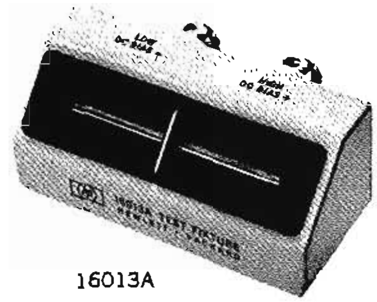
16011A

Converts from BNC to Binding posts.
Price: 16011A, \$43.



16012A

Converts from BNC to test axial lead devices. It has a centrally located guard plane to reduce errors due to stray capacitance.
Price: 16012A, \$48.



16013A

Converts from BNC to test vertical lead devices. It has a guard plane similar to 16012A.
Price: 16013A, \$48.

11143A

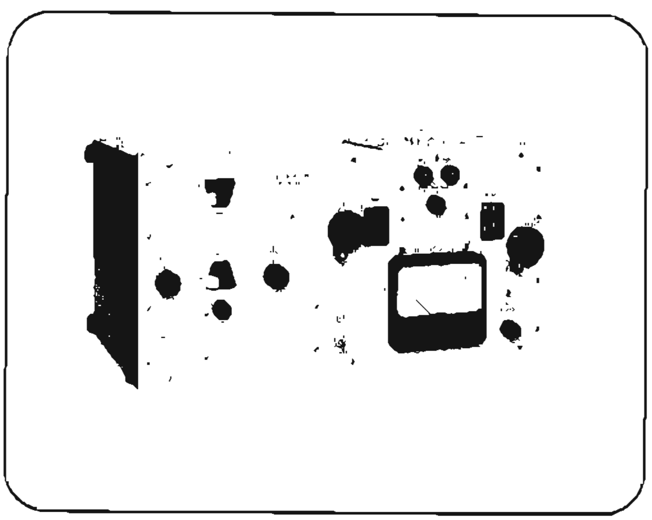
This cable converts from BNC to clip leads. 44″ overall length with third lead to preserve guard terminal.

Approximate stray capacitance: 11 pF between measurement leads, 100 pF between either measurement lead and guard (shield).
Price: 11143A, \$25.

RX METER

Self-contained rf bridge, 500 kHz to 250 MHz

Model 250B



Description

The Hewlett-Packard 250B RX Meter is a self-contained instrument for measuring the equivalent parallel resistance and capacitance or inductance of two-terminal networks. The instrument contains a continuously tuned oscillator, high-frequency bridge and amplifier-detector.

The oscillator is mounted inside a rigid casting to obtain a high degree of accuracy, stability and low leakage.

Specifications, 250B

Frequency range: 500 kHz to 250 MHz; 8 bands.
RF accuracy: $\pm 2\%$.

Resistance measurement characteristics

Resistance range: 15 to 100,000Ω.
Resistance accuracy: $\pm[2 + \frac{F}{200} + \frac{R}{5000} + \frac{Q}{20}]\% \pm 0.2\Omega$; F = frequency (MHz), R = RX Meter R_p reading (ohms), $Q = \omega CR \times 10^{-12}$, where C = RX Meter C_p reading (pF).

Capacitance measurement

Capacitance range: 0 to 20 pF (extended by auxiliary coils).
Capacitance accuracy: $\pm(0.5 + 0.5\ F^2\ C \times 10^{-5})\% \pm 0.15$ pF; F = frequency (MHz), C = RX Meter C_p reading (pF).

Inductance measurement

Inductance range: 0.001 μH to 100 mH.
Inductance accuracy: same as capacitance accuracy.

Measurement voltage level

RF: 0.05 to 0.75 V, depending on frequency. RF level adjustable to 20 mV.
DC: 0 V; (50 mA, external dc, max. may be passed through RX meter terminals).
Accessories available: 00515A Coax Adapter Kit. (Type "N" male connector), \$75; 13510A Transistor Test Jig, \$250.
Dimensions: 20″ wide, 10⅜″ high, 13½″ deep (508 x 264 x 343 mm).
Weight: net, 40 lbs (18 kg); shipping, 50 lbs (22,5 kg).
Power: 105 to 125 V or 210 to 250 V, 48 to 440 Hz, 66 VA.
Price: HP 250B, \$2600.

1 MHz DIGITAL LCR METER
Precision L, C, R & loss measurements
Model 4271A

Description

A new instrument from Hewlett-Packard, the 4271A features automatic high-speed measurements of low value components. The four-pair measurement technique has the advantage of reducing errors due to residual inductance and stray capacitance. User benefits are derived from high accuracy measurements with as many as ten readings per second. Options are available to allow interfacing to Hewlett-Packard's calculators, computers and other data processing equipment.

Specifications*

Capacitance measurement

Function: C-G (Capacitance and Parallel Conductance) or C-D (Capacitance and Dissipation Factor).

Measuring circuit: parallel equivalent circuit with four-pair test terminal.

Ranges

	Range	Capacitance	Conductance	Dissipation Factor
Full range display	1 2 3 4	10.000 pF 100.00 pF 1000.0 pF 10.000 nF	100.00 μʊ 1000.0 μʊ 10.000 mʊ 100.00 mʊ	1.0000
Over-ranging	All ranges	90%	90%	60%

Test signal level	Capacitance	Conductance	Dissipation factor
High	0.1% of rdg. +2 counts	0.2% of rdg. +3 counts	1% of rdg. +0.0010
	0.2% of rdg. +3 counts	0.3% of rdg. +4 counts	1% of rdg. +0.0015

Test signal

Frequency: 1 MHz ±0.01%, 500 mV RMS at high in C-D (all ranges except 10.000 nF range); 20 mV RMS in C-G (all ranges).

Accuracy of level: ±10% for 10 pF to 1000 pF ranges and ±20% for 10 nF range.

Inductance measurement

Function: L-R (Inductance and Series Resistance) or L-D (Inductance and Dissipation Factor).

Measuring circuit: *series equivalent circuit* with four-pair test terminal.

Ranges

	Range	Inductance	Resistance	Dissipation Factor
Full range display	1 2 3 4	1000.0 nH 10.000 μH 100.00 μH 1000.0 μH	10.000 Ω 100.00 Ω 1000.0 Ω 10.000 kΩ	1.0000
Over-ranging	All ranges	90%	90%	60%

Offset adjust: for cancelling residual inductance and resistance.

Offset range: inductance: 100 nH; resistance 100mΩ.

Basic accuracy *(23°C ±5°C)*: (Except lowest range).

Test signal level	Inductance	Resistance	Dissipation factor
High	0.2% of rdg. +3 counts	0.2% of rdg. +3 counts	1% of rdg. +0.0015
Low	0.3% of rdg. +4 counts	0.3% of rdg. +4 counts	1% of rdg. +0.0020

Range	1	2	3	4
	1000.0 nH	10.000 μH	100.00 μH	1000 μH
High	2 mA	5 mA	500 μA	50 μA
Low		200 μA	20 μA	2 μA

HIGH CAPACITANCE METERS
Analog comparator
Models 4350A/B, 4050A

4350A

Description

The Hewlett-Packard Models 4350A/B High Capacitance Meters measure high capacitances from 0.02 μF to 300 mF and simultaneously measure dissipation factor. Leakage current can be measured with the 4350A. The 4350A/B provides analog outputs proportional to meter deflection. Combining the 4350A/B with the 4050A Analog Comparator increases the speed in sorting applications.

Specifications, 4350A/B*
capacitance measurement

Capacitance

Range: 1 μF to 300 mF full scale in 12 ranges.

Accuracy (% of full scale):

	Capacitance Range Full Scale	
Tan δ range	1 μF to 100 mF	300 mF
0 to 1	±3%	±4%
1 to 5	±4%	±5%

Tan δ

Range: 0.5 or 5 full scale in 2 ranges.

Absolute accuracy

0.5 full scale: ± 0.025

5 full scale: $+0.06 + \frac{(\text{reading})^2}{20}$

$-0.06 + \frac{(\text{reading})^2}{25}$

Internal test signal

Frequency: 120 Hz ±5 Hz.

Internal dc bias

Voltage range: 0 to 6 V dc, continuously adjustable.

Response time (C and tanδ): typically 1 s.

Tanδ uncal

Indicates the reading of tanδ is uncalibrated when the deflection of the capacitance meter is below 10% or above 130% of full scale.

Leakage current measurement (4350A only)

Current

Range: 1 μA to 10 mA full scale in 9 ranges.

Accuracy: ±3% of full scale.

DC bias voltage

Internal: up to 100 V dc in 2 ranges.

External: 600 V dc max.

Warning lamp

Indicates "DANGER" when dc voltage across an unknown is higher than 1.5 V dc.

Analog outputs

Capacitance

1 V dc all ranges: for use with analog comparator.

1 V dc or 0.3 V dc full scale: for use with DVM.

Overrange: 25% of full scale.

Accuracy:

	Capacitance Range Full Scale	
Tan δ	1 μF to 100 mF	300 mF
0 to 1	±(1.5% of reading +0.5% of full scale)	±3% of full scale
1 to 5	±(1.5% of reading +1.5% of full scale)	±4% of full scale

Loss angle (δ)

Tan δ vs. analog output voltage: 0.1 V/degree.

Tan δ	δ	Output voltage
0 to 0.5	0° to 26.6°	(0 to 2.66 V dc) ±0.13 V dc
0.5 to 5	26.6° to 78.7°	(2.66 to 7.87 V dc) ±0.3 V dc

Residual noise: 40 mV p-p max.

General

Temperature range: 0°C to 50°C.

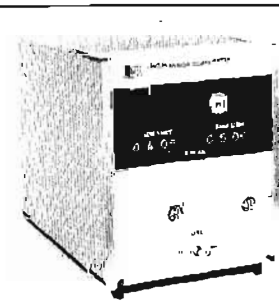
Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 38.5 VA max.

Dimensions: 7-25/32" wide, 6-17/32" high, 12" deep (198 x 166 x 305 mm).

Weight: net 11 lbs (4,8 kg); shipping 15 lbs (6,8 kg).

Accessories furnished: 16035A Test Cable with four alligator clips; 16036A Test Cable with two alligator clips.

Price: HP 4350A, $955.
HP 4350B, $845.



4050A

Description

The Hewlett-Packard Model 4050A Analog Comparator compares the unknown voltage to preset high and low limits. Contact closures with the corresponding (HI-GO-LO) lights will operate external devices. The 4050A increases the speed at which the 4350A/B Hi-C Meter or 4332A LCR Meter will operate in sorting applications.

Specifications, 4050A*

Input

Analog voltage: 0.1, 1, 10 V full scale.

Resistance: 0.1, 1 V range, 1 MΩ; 10 V range, 100 kΩ.

Output

Limit indications: HI, GO, and LO lights.

Relay contact: 3 SPST contacts, 50 V dc, 0.5 A max.

Connector: binding post.

Limit controls: 000 to 125 are set on digital dials.

Accuracy: ±0.6% of full scale (at 25°C).

Response time: typically 0.1 s.

Operating temperature: 0°C to 50°C.

Power: 115/230 V ±10%, 48 Hz to 440 Hz, 3.85 VA max.

Dimensions: standard 1/3 module, 6 3/32" high, 5⅛" wide, 8" deep (155 x 130.1 x 203.2 mm).

Weight: net, 6 lbs, 4 oz (2,8 kg); shipping 8 lbs (3,6 kg).

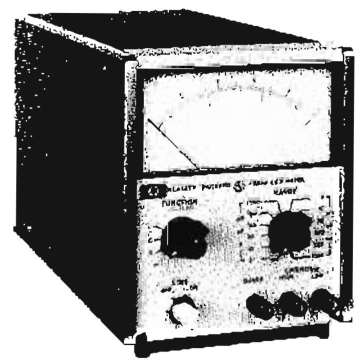
Price: $510.

* Refer to data sheet for complete specifications.

LCR METER
Measures LC and R directly
Model 4332A

Description
Hewlett-Packard Model 4332A LCR Meter measures inductance, capacitance, and resistance. The instrument provides direct readings of L, C and R with linear meter scales. The 4332A is extremely useful for measurements of both linear and nonlinear components. For a rapid Go/No Go test system, combine 4332A with 4050A.

Specifications (at 25°C)
Inductance measurement
Range: 3 μH to 1 H full scale, 12 ranges.
Measuring frequency
3 to 1000 μH, 100 kHz; 3 to 1000 mH, 1 kHz (±5% accuracy).
Accuracy: ± [1% reading + $(1.5 + \frac{3}{Q})$% of FS + 0.03 μH.]
Capacitance measurement
Range: 3 pF to 1 μF full scale, 12 ranges.
Measuring frequency
3 pF to 1000 pF: 100 kHz ±5%
3 nF to 1000 nF: 1 kHz ±5%
Accuracy: ± [1% reading + $(1.5\% + \frac{3}{Q})$ of FS +0.03 pF.]
Resistance measurement
Range: 3Ω to 1 MΩ full scale, 12 ranges.
Measuring frequency: 1 kHz ±5%.
Accuracy
Thru 30 kΩ ranges: ±(0.5% reading +2% FS + 0.03Ω).
100 kΩ to 1000 kΩ ranges: ±(1% reading + 2% FS).

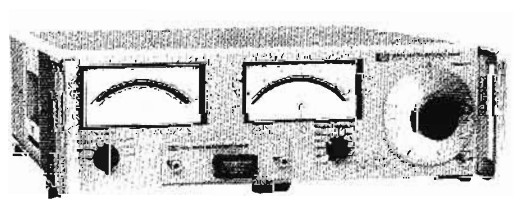

4332A

General
Temperature coefficient (0 to 50°C): ±0.05% full scale/°C.
Analog outputs: 1 V dc and 1 V or 0.3 V dc full scale range.
Input power: 115 V/230 V ±10%, 48 to 66 Hz, 8.8 VA max.
Dimensions: 5⅛" wide, 6-17/32" high, 11" deep.
Weight: net, 7-4/5 lbs; shipping, 10½ lbs.
Price: HP 4332A, $725, with guarded test leads.

VECTOR IMPEDANCE METER
Quickly measures Z & θ, 5 Hz to 500 kHz
Model 4800A

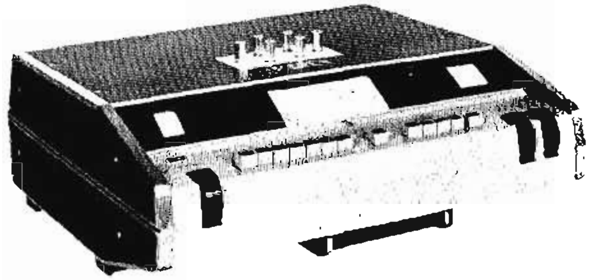
Description
The Hewlett-Packard 4800A Vector Impedance Meter will make fast measurements of impedance to 10 megohms and phase to ±90° of unknown two-terminal networks. Measurement can be made at a particular frequency or over a continuous range from 5 Hz to 500 kHz. The instrument may be mechanically swept to produce continuous measurements over its full frequency range. Analog outputs are available for X-Y recording.

Specifications
Frequency
Range: 5Hz to 500 kHz in five bands.
Accuracy: ±2% from 50 Hz to 500 kHz, ±4% from 5 to 50 Hz, ±1% at 15.92 on frequency dial from 159.2 Hz to 159.2 kHz, ±2% at 15.92 Hz.
Impedance measurement
Range: 1 Ω to 10 MΩ in 7 ranges.
Accuracy: ±5% of reading.
Phase angle measurement
Range: 0° ±90°; accuracy: ±6°.
Direct inductance measurement range: 1 μH to 100,000 H.
Accuracy: ±7% of reading for Q >10 from 159.2 Hz to 159.2 kHz; ±8% of reading for Q >10 at 15.92 Hz.
Direct capacitance measurement range: 0.1 pF to 10,000 μF.
Accuracy: ±7% of reading from D <0.1 from 159.2 Hz to 159.2 kHz, ±8% of reading for D <0.1 at 15.92 Hz.


4800A

Measuring terminal characteristics
Configuration: terminals above ground.
Waveshape: sinusoidal.
Recorder outputs
Frequency: level, 0 to 1 V nominal.
Impedance: level, 0 to 1 V nominal.
Phase angle: level, 0 ±.9 V nominal.
Accessories furnished: 13525A Calibration Resistor, 00610A.
Dimensions: 16¾" wide, 5¼" high, 18⅜" deep (426 x 133 x 467 mm).
Weight: net, 24 lbs (10,8 kg); shipping, 30 lbs (13,5 kg).
Power: 105 to 125 V or 210 to 250 V, 48 to 440 Hz, 29.7 VA.
Price: HP 4800A, $1800.

Q METER
Measures Q,L,C, & resonant frequency
Model 4342A



4342A

Description

The direct-reading expanded scale of the 4342A permits measurement of Q from 5 to 1000 and readings of very small changes in Q resulting from variation in test parameters. The 4342A is solid state with the elimination of specially matched, fragile thermocouple components.

The Q meter consists of a stable, continuously variable oscillator, with automatic level-control. The output is applied in series with an external unknown and an internal variable capacitor. A Q voltmeter with high input Z is connected across the internal variable capacitor portion of the tuned circuit to measure the reactive voltage in terms of circuit Q.

Usefulness

The 4342A will measure dissipation factor and dielectric constant of insulating materials. The Q meter can measure coefficient of coupling, mutual inductance, and frequency response of transformers. RF resistance, reactance, and Q of resistors and capacitors can also be determined.

Internal oscillator

The internal oscillator covers a frequency range from 22 kHz to 70 MHz (10 kHz to 32 MHz in Option 001) in seven bands. This source is automatically leveled to provide a constant injection voltage. This ALC feature eliminates the Q multiplier control found on other Q meters.

Q voltmeter

High stability of the Q Voltmeter eliminates Q-zero adjustment for routine measurements. Accurate information on changes in Q is obtainable on all Q-ranges through the greater resolution (x 10) of delta-Q measurement.

Constant voltage injection system

The 4342A utilizes a constant voltage injection system eliminating the fragile thermocouple system found in other Q meters. The low impedance of this injection system increases Q accuracy.

Rapid inductance measurement

A single "L" point on the frequency dial eliminates the necessity to readjust frequency during inductance measurements.

GO/NO-GO Q selector

The Q-Limit selector will be especially useful for rapid Go/No-Go testing. The high response speed of the Go/No-Go indicator compared to the meter movement is an added feature. External devices may be remotely controlled by the Go/No-Go over limit signal.

Simple, Easier operation

Push-button operation of frequency range and Q/ΔQ range selection provides straightforward measurement. Automatic indictaion of meter scales, frequency dials and frequency multipliers are featured, adding to simplicity and reading speed.

Specifications

RF characteristics

RF range: 22 kHz to 70 MHz in 7 bands: 22 to 70 kHz, 70 to 220 kHz, 220 to 700 kHz, 700 to 2200 kHz, 2.2 to 7 MHz, 7 to 22 MHz, 22 to 70 MHz.

RF accuracy: ±1.5% from 22 kHz to 22 MHz; ±2% from 22 MHz to 70 MHz; ±1% at "L" point on frequency dial.

RF increments: approximately 1% resolution.

Q measurement characteristics

Q range: 5 to 1000 in 4 ranges: 5 to 30, 20 to 100, 50 to 300, 200 to 1000.

Q accuracy: % of indicated value, (at 25°C).

Q \ Freq.	22 kHz - 30 MHz	30 MHz - 70 MHz
5 - 300	±7	±10
300 - 600	±10	±15
600 - 1000	±15	±20

Q increments: upper scale: 1 from 20 to 100, lower scale: 0.5 from 5 to 30.

ΔQ range: 0 to 100 in 4 ranges: 0 to 3, 0 to 10, 0 to 30, 0 to 100.

ΔQ accuracy: ±10% of full scale.

ΔQ increments: upper scale: 0.1 from 0 to 10, lower scale: 0.05 from 0 to 3.

Inductance measurement characteristics

L range: 0.09 μH to 1.2 H, direct reading at 7 specific frequencies.

L accuracy: ±3% after substitution of residuals (approx. 10 nH).

Resonating capacitor characteristics

Capacitor range: main dial: 25 to 470 pF; vernier dial −5 to +5 pF.

Capacitor accuracy: main dial: ±1% or 1 pF, whichever is greater; vernier dial ±0.1 pF.

Capacitor increments: main dial: 1 pF from 25 to 30 pF, 2 pF from 30 to 200 pF, 5 pF from 200 to 470 pF; vernier dial: 0.1 pF.

General

Rear panel outputs

Frequency monitor: 170 mV rms min. into 50Ω.

Q analog output: 0 to 1 V ±50 mV dc after 15 minutes warm-up, proportional to meter deflection. Output impedance approximately 1 kΩ.

Over limit signal output: contact closure at the rear panel. Relay contact capacity 0.5A/15 VA.

Over limit display time: selectable, 1 s or continuously on, after limit exceeded.

Temperature range: 0°C to 50°C.

Power: 115 or 230 V ±10%, 48-440 Hz, 27.5 VA max.

Dimensions: 16¾" wide, 5-1/16" high, 16-5/16" deep (425 x 138 x 414 mm).

Weight: net, 31 lbs (14 kg); shipping, 41 lbs (18,45 kg).

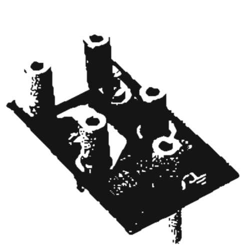
Price: Model 4342A, $1665.

5 - 300	300 - 600	600 - 1000
≈7	≈10	≈15

Price: Model 4342A Opt 001, $1800

Accessories for 4342A Q Meter*

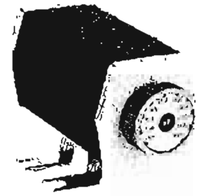
Series loss test adaptor



The 16014A Series Loss Test Adaptor is designed for measuring low impedance components, low-value inductors and resistors, and also high-value capacitors. Using the adaptor adds convenience in connecting components in series with the test circuit of the 4342A Q Meter. This adaptor consists of a teflon printed-circuit base on which are mounted binding posts, to accept the Reference Inductors, and a pair of low-inductance series terminals for the unknown.

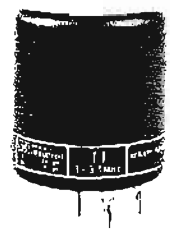
Usable frequency range: 10 kHz to 10 MHz

Price: HP 16014A, $38.



Auxiliary capacitor

The 16462A Auxiliary Capacitor is designed to extend the Q and L measurement capability of the 4342A Q Meter. It is especially useful for measuring small inductors at low frequencies.
Price: HP 16462A, $165.



Reference inductors*

A range of 20 inductors, any of which can be supplied separately, is available for use with the 4342A Q Meter for measuring the RF characteristics of capacitors, resistors, and insulating materials. These inductors have three terminals. One terminal is connected to the case to stabilize measurements.

Price: HP 16471A through HP 16490A, and HP 16465A, $28 each. HP 16470A set of twenty (16471A-16490A), $445.

Q standards*

The 00513A and 00518A Q standards are hermetically sealed reference inductors having accurately measured, highly stable inductance and Q characteristics. These Q standards are particularly useful for checking the overall operation and "accuracy" of Q-meters.

Prices: HP 00513A, HP 00518A, $125 each (set of one HP 00513A and five HP 00518A, order HP 00538A, $675).

*Refer to data sheet for complete specifications.

Q METER

Direct Q measurement 20 to 260 MHz

Model 190A

Description

The Hewlett-Packard 190A Q Meter finds applications in the VHF range of frequencies. This instrument employs a special coupling impedance to introduce voltage across the resonant circuit. This voltage, as well as the voltage across the internal Q capacitor, is measured by two vacuum tube voltmeters and indicated on a single meter.

Specifications, 190A

Frequency range: 20 to 260 MHz; 4 bands.

RF accuracy: ±1%.

Q measurement

- **Q range:** total range: 5 to 1200; low range; 10 to 100.
  - **△ range:** 0 to 100.
- **Q accuracy:** ±7% 20 to 100 MHz: ±15% 100 to 260 MHz (for circuit Q of 400 read directly).

Resonating capacitor characteristics

- **Capacitor range:** 7.5 to 100 pF.

Capacitor accuracy: ±0.2 pF, 7.5 to 20 pF; ±0.3 pF, 20 to 50 pF; ±0.5 pF, 50 to 100 pF.

Capacitor calibration: 0.1 pF increments.

Accessories available: 00590A Reference Inductors.

Physical characteristics

Dimensions: 14¼" wide, 10⅛" high, 10½" deep (362 x 257 x 267 mm).

Weight: net, 25 lbs (11,3 kg); shipping, 32 lbs (14,4 kg).

Power: 190A: 95 to 130 V, 60 Hz, 60.5 VA max; 190AP: 115/230 V, 50 Hz, 60.5 VA max.

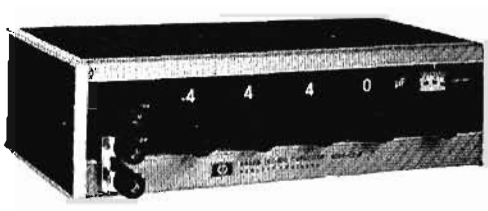
Price: HP 190A, AP, $1600.

ATTENUATORS & CAPACITOR

Variable with increments of 0.1 dB or 2 pF

Models 4440B, 4436A, 4437A, 350D

Decade Capacitor, Model 4440B



4440B

The Hewlett-Packard 4440B Decade Capacitor is a high accuracy instrument providing usable capacitances from 40 pF to 1.2 μF. Its 0.25% accuracy makes it an ideal aid for circuit design or as a working standard.

Use of silvered-mica capacitors in four decades of 100 pF provides higher accuracy, low dissipation factors and good temperature coefficient. An air capacitor vernier provides 100 pF (from 40 pF to 140 pF) with resolution of 1 pF. Capacitors are housed in a double shield in such a way that increased capacitance from two terminals to three terminals is held to 1 pF.

Specifications, 4440B

Capacitance: 40 pF to 1.2 μF in steps of 100 pF with a 40 pF to 140 pF variable air capacitor providing continuous adjustment to better than 2 pF between steps.

Direct reading accuracy: ±(0.25% + 3 pF) at 1 kHz for three-terminal connection.

Resonant frequency: typical values of the resonant frequency are 450 kHz at 1 μF, 4 MHz at 0.01 μF and 40 MHz at 100 pF.

Dissipation factor: 0.001 maximum at 1 kHz.

Temperature coefficient: +70 ppm/°C.

Insulation resistance: 5 GΩ minimum, after 5 minutes at 500 V dc.

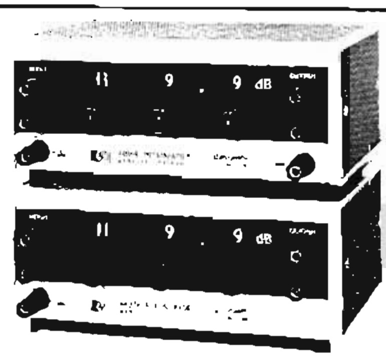
Maximum voltage: 500 V peak.

Weight: net, 5½ lbs (2,5 kg); shipping, 8 lbs (3,6 kg).

Dimensions: 11" wide (264 mm), 6" deep (152 mm), 3" high (76 mm).

Price: HP 4440B, $340.

Attenuators, Models 4436A/4437A



4436A

4437A

The Hewlett-Packard Models 4436A/4437A Attenuators provide accurate steps of attenuation with 0.1 dB resolution for power-level measurements, communication system tests, and gain or loss measurements on filters and amplifiers, and similar equipment.

Specifications, 4436A

Maximum attenuation: 119.9 dB.

Attenuation increments: 0.1 dB.

Input/output impedance: 600Ω, balanced.

Frequency range: dc to 1.5 MHz (0 to 110 dB) dc to 1 MHz (0 to 119.9 dB).

Accuracy

Attenuation	100 kHz	1 MHz	1.5 MHz*
0 ~ 60 dB	±0.1 dB	±0.2 dB	±0.2 dB
60 ~ 90 dB	±0.1 dB	±0.3 dB	±0.3 dB
90 ~ 110 dB	±0.2 dB	±0.5 dB	±0.5 dB
110 ~ 119.9 dB	±0.3 dB	±0.1 dB	

*Typical value

Maximum input power: +30 dBm.

DC isolation: signal ground may be ±300 V dc from external chassis.

Dimensions: 7¾" wide, 3" high, 6⅝" deep (198 x 77 x 167 mm).

Weight: net, 3.3 lbs (1,5 kg); shipping, 6 lbs (2,7 kg).

Price: Model 4436A, $500.

Specifications, 4437A

The Model 4437A is a 600 ohms unbalanced type, and its specifications are identical to the 4436A.

Price: Model 4437A, $345.

Attenuator, Model 350D

Two attenuator sections make up the Hewlett-Packard 350D Attenuator. One section is a 100 dB attenuator, adjustable in 10 dB steps. The other is a 10 dB attenuator, adjustable in 1 dB steps.

Specifications, 350D

Attenuation: 0 to 110 dB, 1 dB and 10 dB steps.

Power capacity: 600Ω unbalanced; 5 W (55 V dc or rms) max, continuous duty.

DC isolation: signal ground may be ±500 V dc from chassis.

Accuracy

10 dB section

	0 dB – 10 dB
dc to 100 kHz	< ±0.125 dB/step
100 kHz to 1 MHz	< ±0.25 dB/step

100 dB section

	0 dB – 70 dB	70 dB – 100 dB
dc to 100 kHz	< ±0.25 dB	< ±0.5 dB/step
100 kHz to 1 MHz	< ±0.5 dB	< ±0.75 dB/step

Dimensions: standard Hewlett-Packard 1/3 module 5⅛" wide, 6¼" high, 8" deep (130 x 159 x 203 mm).

Weight: net, 4 lbs (1,8 kg); shipping, 6 lbs (2,7 kg).

Price: HP 350D, $165.

Digital voltmeters

Digital voltmeters (DVM's) offer many advantages over other types of voltmeters. Among the advantages of DVM's are greater speed, greater accuracy and resolution, reduction of operator errors, and the ability to be remotely controlled or to remotely control another device, such as a printer.

Digital voltmeters display measurements as discrete numerals, rather than as a pointer deflection on a continuous scale, which is commonly used in analog devices. Direct numerical readout in DVM's reduces human error and tedium. Automatic polarity and range-changing features reduced operator training, and possible instrument damage through overload.

Digital voltmeters are available to measure ac and dc voltages, current, resistance and ratio. Suitable transducers may be used to measure other parameters such as strain or temperature. One of the most important features of a DVM is its ability to be used in an automatic system. Many DVM's have a digital output to make permanent records of measurements with printers, tape punches, etc. Digital output allows the data to be entered into a computer or calculator for automatic data reduction. Remote control is also available on many DVM's to allow a system to make range and function changes.

Converters

The A-to-D converter in a digital voltmeter measures dc. Other quantities to be measured must be presented to the A-to-D converter in the form of a dc voltage. This necessitates the use of ac converters, etc.

AC converters can be classified according to their response to the input signal. The average responding converter is relatively inexpensive and was designed primarily for measurement of sine waves having little or no distortion. This type of converted measures the average value of the rectified waveform, which is then multiplied by a scale factor to provide the rms value.

The true rms converter responds to the effective heating value of the waveform. A thermocouple or thermopile (a thin film series of thermocouples) is used to convert the input signal, first to heating effect on a resistor, then to its equivalent dc voltage. The measurement is free from errors due to distortion. True rms converters may also be used to measure non-sinusoids. Some Hewlett-Packard true rms converters measure the heating value of a dc signal mixed with an ac signal. The composite equals $\sqrt{(dc)^2 + (ac\ rms)^2}$.

These dc coupled converters have wider bandwidth. For example, HP's 3403C can measure dc, plus 2 Hz to 100 MHz. In most cases, true rms converters are more expensive than average responding types. However, true rms converters offer many advantages. Besides wider bandwidths, it assures measurement confidence because true rms converters eliminate large errors due to small amounts of sinusoidal distortion.

Ohms converters fall into three categories: two-wire, three-wire, and four-wire. The two-wire converter is the most common and the most economical, but it is sensitive to lead resistance. For example, if low resistance values are being measured at a remote location, lead resistance will cause an error in the measurement. A three-wire converter may have four terminals on the front panel, and may even be called a four-wire converter. It is also sensitive to lead resistance, especially on the low side of the input, but it may be possible to null out the error caused by the lead resistance with an internal adjustment. The true four-wire converter has a fully isolated current source and is insensitive to lead resistance. It makes low ohms ranges useful for remote measurements. This scheme offers the ultimate in performance for ohms measurements.

Resolution and sensitivity

DVM's are generally classified according to the number of digits. The number of digits is often confused with the overrange digit. For example, a five-digit display of "19999" really only has four *full* digits; i.e., four "9's." The extra "1" is an overrange digit which allows the user to read beyond full scale. Overranging greatly extends a DVM's usefulness by increasing resolution. For example, if a signal changes from 9.999 V to 10.012 V, a four-digit DVM *without* overranging could measure the first voltage as "9.999 V," but would require a range change to make the second measurement with a resulting reading of "10.01 V." The 0.002 V change would not be seen. But *with* overranging, the second measurement could be made as "10.012V" with no loss of resolution.

Overranging is given as a percentage. A four-digit DVM with 100% overranging would have a maximum display of "19999."

Resolution is usually shown as a full scale display plus X% overranging. A five-digit DVM with 20% overranging has resolution of one-part in 119,999. Sensitivity is usually given as the lowest full scale range or the smallest visible increment in voltage. A four-digit DVM with a 100 mV lowest range could be said to have a sensitivity of 10 μV (100.00 mV, last digit equals 10 μV).

Accuracy

Accuracy is the exactness to which voltage can be determined, relative to the Legal Volt maintained by the National Bureau of Standards. A manufacturer must maintain calibration standards which can be traced back to the Legal Volt before an accuracy specification can be given to a DVM. The accuracy specification equals the errors involved in traceability as well as the errors made by the instrument.

To be meaningful, accuracy must be stated along with the conditions under which it will hold. These conditions include time, temperature, line variations and humidity. Accuracy should hold over a meaningful temperature range, such as ±5°C, unless the DVM is to be operated in a tightly controlled environment.

The period of time over which accuracy holds is especially important since it indicates the DVM's stability and how often it will have to be calibrated.

Accuracy is usually stated in two parts: a percent of reading and a percent of range (or full scale). The percent of reading is often related to analog error and the percent of full scale is scale often related to digital error. Accuracy is always better at or above full scale.

Specification difference between accuracy and short term stability for a typical four-digit DVM is shown in figure one.

Figure two shows how the accuracy of a typical four-digit DVM improves as percent of full-scale increases to 100. The least error is in the overrange region.

A DVM user needs to know three things about the speed of a DVM he is about to purchase: 1) the time required

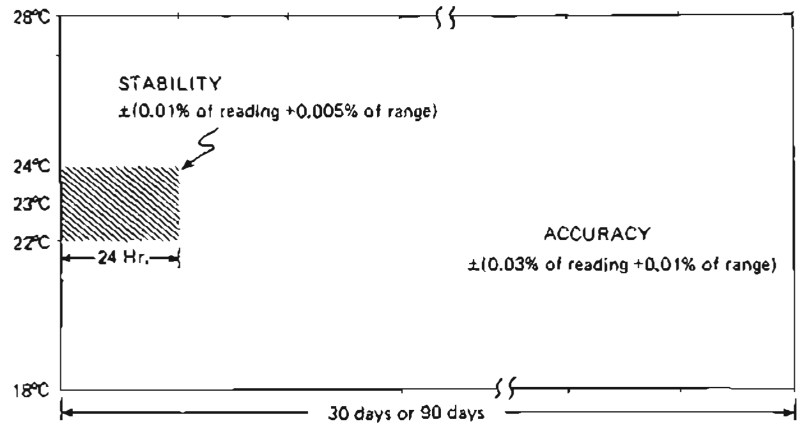


Figure 1. Accuracy and short term stability of a typical four-digit DVM.

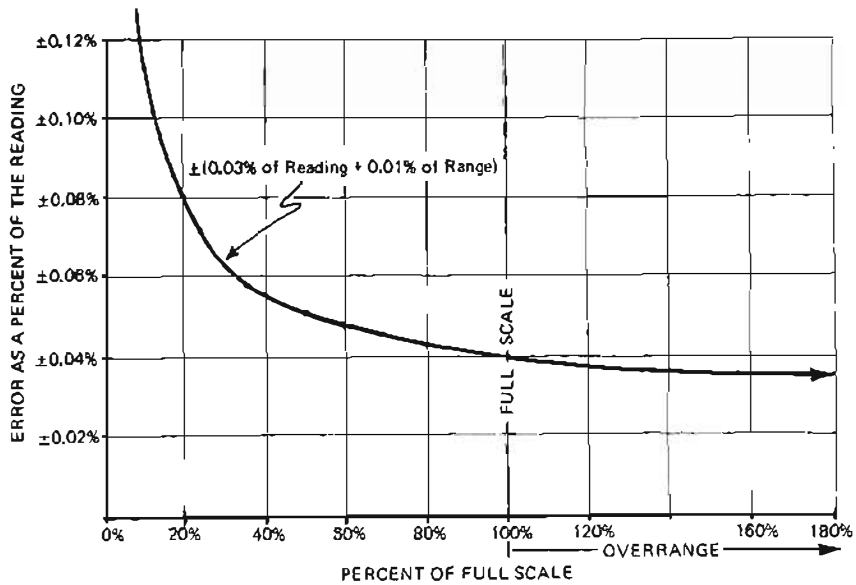


Figure 2. Typical four-digit DVM accuracy.

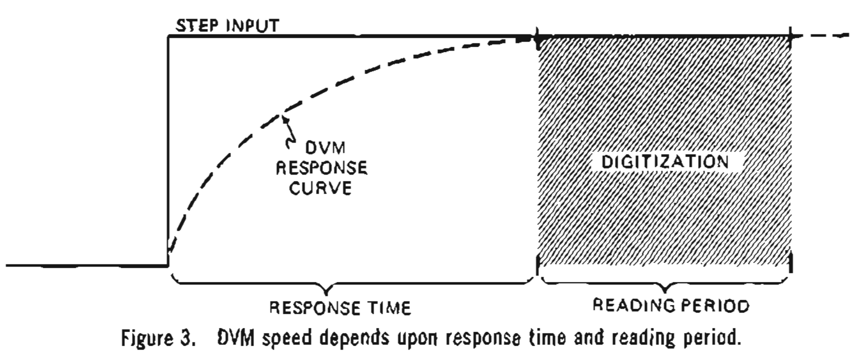


Figure 3. DVM speed depends upon response time and reading period.

to respond with an accurate reading after application of an input signal, 2) the effect on speed of any input filtering, and 3) the reading rate when the DVM is used in a system.

Most DVM's have their own internal trigger source which may be adjustable from the front panel or fixed. Quite often, the trigger source is independent of response time. For example, a DVM may have a fixed sample rate of five readings per second, which is fine for dc measurements, but the ac converter may take two seconds to respond. This means that only the 19th reading after application of the ac signal will be correct. This works fine for bench measurements where the user waits for a steady reading. Figure three shows that DVM speed is determined by the settling time of its input amplifier, plus the time required to digitize the signal.

For system use, the DVM's internal trigger is not used. External triggers are issued by the system incorporating the appropriate delay to allow for settling. Some DVM's, especially those designed for systems, have a built-in delay to produce the correct reading on the first measurement.

The time required to reject noise may involve filtering which becomes part of the response time, or it may involve integration which is part of the time required to digitize the input voltage. Whichever technique is used, one rule applies: the better the noise rejection, the longer the response time.

The time to digitize the input signal is called, "the reading period." Typically, it varies from 950 microseconds up to 9.1 seconds depending upon the DVM. If autoranging is used, it will add to this time.

Noise rejection

The source and type of noise are important in determining the type of noise rejection needed.

Normal-mode noise enters with the signal and must be eliminated by the DVM's measuring technique. Filtering is the simplest way to cut down on noise but it slows the measurement speed. Integration "calculates" the noise out of the measurement by looking at the input signal over a time period equal to the period of the expected noise. Filtering is advantageous for rejecting broadband noise with the added benefit of being flexible: speed may be traded for noise rejection. Integration is better for rejecting line related noise and achieves close to perfect rejection at line frequencies and multiples of line frequency.

Common-mode noise appears between the DVM's input terminals and ground. It is usually caused by grounding differences between the device being measured and the instrument. A floating dc measurement has a dc common-mode signal.

Errors caused by common-mode noise may be reduced by a passive technique called "guarding." Guarding shunts the noise to ground and away from the input terminals. Physically, a guard is a box surrounding the measurement circuit but insulated from it. The guard shield is brought out to the front panel as a terminal. By proper connection of the guard, a remarkable improvement can be seen in a DVM's ability to reject common-mode noise.

"Effective" common-mode rejection is usually what appears on a data sheet. Effective means, the effect on the final reading. The effective CMR is the combined result of "pure" CMR due to guarding or good shielding, *plus* the normal-mode rejection of the instrument.

Table 1. HP DVM Selection Guide

Model	Number of Digits	Overranging	DC Accuracy	Maximum Speed	DC Volts	AC Volts	Ohms	DC Current	Ratio	Autoranging	BCD Output	Remote Control	Scanning Capability	Sample-and-Hold
3469B	3	100%	±0.2%	15/s	X	X	X	X						
3403C	3	90%	±0.4%	2/s	X	X				X	X	X		
3440A + Plug-ins	4	5%	±0.06%	5/s	X	X	X	X		X	X	X		
3470 Series	4 or 5	100%	±0.04%	5/s	X	X	X	X		X	X			
3480A/B + Plug-ons	4	50%	±0.02%	1000/s	X	X	X			X	X	X	X	X
2402A	5	30%	±0.013%	43/s	X	X	X			X	X	X		
3450B	5	20%	±0.01%	15/s	X	X	X		X	X	X	X		
3460B	5	20%	±0.006%	15/s	X					X	X	X		
3490A	5	20%	±0.012%	5/s	X	X	X		X	X	X	X		X
3462A	6	20%	±0.0042%	1/s	X					X	X	X		

Table 2. HP DVM's with AC Converters

Model	Ranges Sensitivity	Frequency Range	Response	Input Impedance
3469B	1 mV to 1000 V 1 μV	20 Hz to 10 MHz	Average	10 MΩ / / 25 pF
3403C	10 mV to 1000 V 10 μV	2 Hz to 100 MHz	True RMS	10 MΩ / / 19 pF
3440A (3445A)	10 V to 1000 V 1 mV	50 Hz to 100 MHz	Average	10 MΩ / / 20 pF
3470 Series (34702A)	1 V to 1000 V 100 μV	45 Hz to 100 kHz	Average	10 MΩ / / 65 pF
3480A/B (3484A)	100 mV to 1000 V 10 μV	1 Hz to 10 MHz	True RMS	2 MΩ / / 45 pF
2402A (Opt 002)	1 V to 1000 V 10 μV	50 Hz to 100 kHz	Average	0.9 MΩ / / 200 pF
3450B (Opt 001)	1 V to 1000 V 10 μV	45 Hz to 1 MHz	True RMS	2 MΩ / / 90 pF
3490A	1 V to 1000 V 10 μV	20 Hz to 250 kHz	Average	2 MΩ / / 65 pF

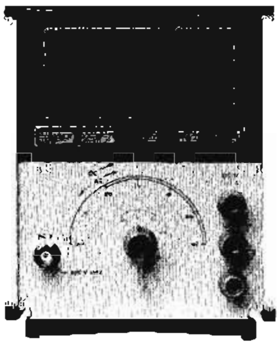
Table 3. HP DVM's with ohms Converters

Model	Ranges	Sensitivity	2-Wire	4-Wire	Current Through 1 kΩ Resistor
3469B	1Ω to 10 MΩ	1 mΩ	X		1 mA
3440A (3444A)	1 kΩ to 10 MΩ	100 mΩ	X		1 mA
3470 Series (34702A)	100Ω to 10 MΩ	10 mΩ	X		1 mA
(34703A)	1Ω to 10 MΩ	0.1 mΩ		X	1 mA
3480A/B (3484A)	100Ω to 10 MΩ	10 mΩ	X		1 mA
2402A (Opt 003)	1 kΩ to 10 MΩ	10 mΩ		X	1 mA
3450B (Opt 002)	100Ω to 10 MΩ	1 mΩ		X	1 mA
3490A	100Ω to 10 MΩ	1 mΩ		X	1 mA

DIGITAL MULTIMETER

High sensitivity, high performance multimeter

Model 3469B



3469B

Description

Twenty-six different range and function combinations allow a wide variety of measurements of ac volts, dc volts, ohms, and dc current.

High sensitivity, wide bandwidth ac voltmeter

High sensitivity (2 mV to 500 V full scale) wide bandwidth (20 Hz to 10 MHz), and high accuracy (±.6% to 5%).

High sensitivity milliohmmeter

Resistance sensitivity (1Ω to 10 MΩ full scale) allows fast and accurate measurements of contact resistances, components, and plated-through circuit board hole resistances.

Digital dc ammeter

High current sensitivity (2 μA to 200 mA full scale) allows current measurement capability approaching electrometer type performance at a modest price.

DC voltmeter

Fast dc measurements (15 samples per second), good sensitivity (200 mV to 1000 V full scale), and good accuracy (±0.2% to ±0.3%).

Specifications

AC voltmeter

Ranges: 1 mV, 10 mV, 100 mV, 1 V, 10 V, 100 V, 1000 V (500 V max input).

Accuracy above 1% of range ±(% reading + % range), 20°C to 30°C.

1 mV range (0.3 mV and above):

20 Hz 100 kHz 4MHz

1 + 0.75	2.5 + 2.5

10 mV to 1 V ranges:

20 Hz 100 Hz 100 kHz 1 MHz 10 MHz

0.5 + 0.5	0.3 + 0.3	1 + 1	2.5 + 2.5

10 V, 100 V, 1000 V ranges:

20 Hz 100 Hz 100 kHz 1 MHz 4 MHz

1 + 0.5	0.4 + 0.3	1 + 1	2.5 + 2.5

Input impedance: 10 MΩ shunted by <25 pF. Input common connected to chassis.

Overload protection: 500 V at frequencies ≤60 Hz.

Residual noise: <75 μV.

DC voltmeter

Ranges: 100 mV, 1 V, 10 V, 100 V, 1000 V.

Accuracy (20°C to 30°C)

100 mV range: ±(0.2% reading +0.1% range).

1 V to 1000 V ranges: ±(0.1% reading +0.1% range).

Input impedance: 10 MΩ.

Response time: 70 ms.

Overload protection: 1000 V.

Normal mode rejection

60 Hz: 40 dB.

Common mode rejection

DC: 60 dB.

Floating voltage: ±500 V max.

Ohmmeter

Ranges: 1Ω*, 10Ω, 100Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ.

Accuracy (20°C to 30°C)

1Ω range: ±(0.25% reading + 0.5% range).

10Ω range: ±(0.3% reading + 0.2% range).

100Ω to 10 MΩ range: ±(0.2% reading + 0.2% range).

Source characteristics

Full scale range	Short circuit current
1Ω **	10 mA
10Ω	10 mA
100Ω	10 mA
1kΩ	1 mA
10kΩ	0.1 mA
100kΩ	10 μA
1MΩ	1 μA
10MΩ	0.1 μA

**Cable resistance offset adjust on rear panel.

Open circuit voltage: 10 V negative with respect to common (common connected to chassis).

Response time

10Ω to 10 MΩ ranges: 70 ms.

DC input protection: ±100 V max.

AC input protection: 130 V rms max.

DC ammeter

Ranges: 1 μA, 10 μA, 100 μA, 1 mA, 10 mA, 100 mA.

Accuracy (20°C to 30°C): ±(0.2% reading +0.2% range).

Full scale voltage drop: 100 mV.

Response time: 70 ms.

Overload protection: 5 times full scale.

Floating voltage: ±500 V max.

General

Sample rate: 15/s.

Overrange: 100%.

Display: GaAsP light emitting diodes.

Out of range and illegal range indication: 3 least significant digits blank.

Polarity: automatic.

Operating temperature range: 0°C to 55°C.

Warmup: 10 min.

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 10 VA.

Dimensions: 5⅛" wide, 16¼" high (without removable feet), 11" deep (130 x 159 x 279 mm).

Weight: net, 7 lbs (3.15 kg); shipping, 9 lbs (4 kg).

Price: HP 3469B, $640.

*Allowable reactance <100 μH series, <2 μF parallel.

TRUE RMS VOLTMETER
DC/2 Hz - 100 MHz, dB/volts display
Model 3403C

NEW▶

3403C

Description

A new true rms voltmeter that covers nearly the whole spectrum of ac measurements is announced by Hewlett-Packard. A truly general-purpose device, this new Model 3403C RMS Digital Voltmeter measures dc plus ac from 2 Hz to 100 MHz. Using a three digit LED display with a fourth digit for overrange, the DVM reads both in volts, and with an option, decibels. AC voltage is measured from 10 millivolts to 1000 volts full scale. The instrument reads dBV from —60 to +60.

All this capability is in a small 4½ by 7¾ by 9½ inch package. The Model 3403C is usable for dc, low frequency, audio, RF and IF measurements. True rms is especially valuable for measurements of noise, multiplexed signals, modulated waves and other complex signals with high harmonic content. Previously, a user had to purchase an expensive DVM with an ac option with limited upper bandwidth, or an RF voltmeter with limited low frequency ability. Now, wide bandwidth and wide voltage range are available in one instrument.

New design technology in the Model 3403C includes a thin-film hybrid dc to 100 MHz amplifier, a log converter on a temperature-controlled chip, a thin-film thermopile, a panel meter using the Hewlett-Packard solid-state display, and MOS, LSI circuitry. The solid-state display section is a one-volt digital panel meter that is sold by Hewlett-Packard as a separate product.

A full range of options is available including autorange, BCD output and remote programmability for systems applications. Analog outputs proportional to volts and decibels are available for use with analog recording devices.

Wide voltage range

The 3403C has six ac voltage ranges from 10 mV full scale to 1000 V full scale, enough to satisfy an extremely wide range of applications. In addition, the 3403C provides five dc ranges and five dc + ac ranges for dc and low frequency measurement capability. This wide measuring span covers virtually any ac requirement and makes the instrument a truly general purpose device.

Wide bandwidth

The dc and 2 Hz to 100 MHz bandwidth of the 3403C allows usage throughout the frequency spectrum. The 3403C is not only a general purpose meter for audio and low RF use, but it also can be used in the upper RF and IF bands. The 3403C, in addition, is a low frequency measurement instrument and a five range dc meter.

True rms

The 3403C is a true rms responding instrument utilizing the Hewlett-Packard thermopile as the rms sensing element. Its rms capability enables the 3403C to make meaningful measurements of noise, multiplexed signals or other complex or distorted waveforms, as well as providing the assurance that any general purpose measurement will be made accurately.

dB Display

The dB display option provides readings directly in dB, a major convenience to ac users. The dB reference to which the measurement is made is conveniently adjustable from the front panel both; to provide referenced dB measurements, or to provide a convenient means to offset the reading by as much as 13 dB for unreferenced measurements.

Systems

A full complement of systems options is available, both isolated and nonisolated, to insure systems compatibility.

The 3403C may be used with Hewlett-Packard printers and may easily be integrated into more complex systems remote control.

Solid state display

The 3403C uses the Hewlett-Packard digital panel meter with its light emitting diode display as a readout device. This display provides a pleasing appearance, ruggedness and high reliability.

Specifications

Ranges

Full range display: 10.00 mV (ac only); 100.0 mV, 1.000 V, 10.00 V, 100.0 V, 1000 V.

Overrange: >90% on all ranges except as limited by max input voltage.

Ranging information: front panel annunciators indicate overrange (approximately 190% of full range), or underrange (approximately 17% of full range) conditions.

Performance

AC frequency range

Slow response: 2 Hz to 100 MHz.

Fast response: 25 Hz to 100 MHz.

Response time

Fast response: 1 s.

Slow response: 10 s.

Instrument reads final reading ±0.1% of input change in stated response time.

Display rate

Fast response: 4 readings per s.

Slow response: 2 readings per s.

Functions

DC: responds to dc component of input signal.

AC: responds to true rms value of ac coupled input signal.

AC + dc: responds to true rms value of dc and ac input signal; reading is $\sqrt{(dc)^2 + (ac\ rms)^2}$.

Temperature coefficient: ±0.1 x reading accuracy*/°C outside the 25°C ± 5°C temperature range.

*data from accuracy charts.

Accuracy: 90 days (25°C + 5°C, <95% RH, 17% of range to 190% of range).

READING ACCURACY = ± % OF RANGE + ± % OF READING **

RANGE	VOLTS DC	VOLTS DC + AC	VOLTS AC	+	FREQUENCY (Hz) DC	2	25	100k	1M	10M		100M
1000V	.3	.3	.3		.2	.4*	.2					
100V	.2	.2	.2		.2	.4*	.2	1				
10V	.2	.2	.2		.2	.4*	.2	.5	1			
1V	.2	.2	.2		.2	.4*	.2	.5	1	2	5	10
100mV	.6	.6	(4mV) .2 / .4		.2	.4*	.2	.5	2	2 (20M)	5 (50M)	10
10mV			(4mV) .2 / .4				.3	1	3 (2M)			

CAUTION: frequencies and ranges in this area may result in invalid readings without ranging indication.

* DC + AC function and slow response time only.

** % of reading specification is representative of typical flatness.

Input characteristics

Input Impedance: <10 MHz.

1 V to 1000 V range: 10 MΩ ±10% shunted by 19 pF ±10%.

10 mV and 100 mV range: 20 MΩ ±10% shunted by 16 pF ±10%.

10 MHz to 100 MHz: the following table gives maximum loading due to input shunt impedance across a terminated source.

System impedance (source and load)	Frequency 10 MHz	100 MHz
50Ω	1%	10%
75Ω	2%	20%

2 Hz to 25 Hz	2:1 at full range input.
>25 Hz	10:1 at full range input.

Maximum input voltage

Hi to Lo:

1000 V rms, 1500 peak or 10[8] V-Hz on any range. Maximum dc voltage in ac mode: 500 V dc.

Lo to chassis:

±500 V dc, when floated with special banana to BNC adapter.

Options

Autoranging (3403C Option 001)

Automatic ranging: uprange at approximately 190% of full range; downranges at approximately 17% of full range.

Autorange time: fast response: 1 s per range change. Slow response: 10 s per range change.

Digital output (3403C Option 002)

The digital output option provides data outputs in digital form for printer and system applications. In addition, input lines are included for external triggering of the instrument.

Isolated remote control + digital output + autoranging (3403C Option 005).

In addition to the features of Option 003, Option 005 provides the same isolation characteristics as isolated digital output (Option 004).

dB display (3403C Option 006)

Measurement range: 108 dB (−48 dB V to +60 dB V).

Accuracy: 90 days (25°C +5°C, <95% RH).

READING ACCURACY = ± dB + ± dB **

RANGE	dB AC	dB DC + AC	+	FREQUENCY (Hz) DC	2	25	100k	1M	10M		100M
1000V	.15	.15		.02	.04*	.02					
100V	.15	.15		.02	.04*	.02	.1				
10V	.15	.15		.02	.04*	.02	.05	.1			
1V	.15	.15		.02	.04*	.02	.05	.1	.2	.5	1
100mV	.15	.15		.02	.04*	.02	.05	.2	.2 (20M)	.5 (50M)	1
10mV	.15					.03	.1	.3 (2M)			

CAUTION: frequencies and ranges in this area may result in invalid readings without ranging indication.

* DC + AC function and slow response time only.

** specification is representative of typical flatness

Calibrated dB reference: 0 dB = 1.000 V; reference level may be set for 0 dBm (600 Ω) by adjusting front panel dB calibration adjustment.

Variable dB reference: reference level may be shifted downward from calibrated position by >13 dB.

dB recorder output: output voltage: 200 mV for 20 dB. Output resistance: 1 kΩ ±500 Ω.

General

Operating conditions

Temperature range: 0°C to 50°C.

Humidity: <95% RH.

Recorder output

Output voltage: 1 V dc open circuit for full range input.

Output resistance: 1 kΩ ±10%.

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 35 VA max. (including all options).

Input terminals: BNC front panel connector standard for Lo to Hi terminals: rear panel connector available by internally reversing position of ac converter module.

Weight: including all options: net, 11 lbs (5 kg); shipping, including all options: net, 16 lbs (7,2 kg).

Dimensions: 9¼″ wide, 5″ high, 7¾″ deep (234,9 x 127 x 196,8).

Accessories furnished: floating adapter—banana to BNC.

Price: HP 3403C $1500; **Option 001 autoranging,** add [illegible]; Option 002 digital output, add [illegible]. *Option 005 isolated remote control + digital output + autoranging, add [illegible]. *Option 006 dB display, add $250.

*Options 005 and 006 are available only as factory installed options.

MEASUREMENT SYSTEM
Four-digit DVM with interchangeable modules
Model 3470 Series

Description

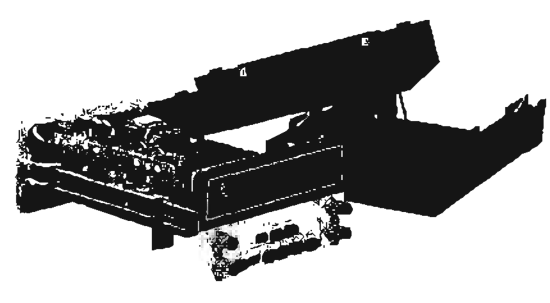
The Hewlett-Packard 3470 Series is a low-cost line of DVM's using a flexible snap-together package. Two display sections are available, a four-digit display and a five-digit display, both with 100% overranging and a clear easy-to-read LED readout. These display sections lock onto any of three voltmeter modules which include a dc voltmeter, an AC/DC/Ohm multimeter and a DC/DCI/Ohm high sensitivity voltmeter. In addition, three center sections are available, including a battery pack and a BCD module. The third section (center) provides greater sensitivity and ac/dc current capability when used with the AC/DC/Ω multimeter.

The front panel of the 3470 Series is designed to save time and confusion. Functions and ranges are clearly labeled. All maximum voltages are indicated at the input terminals. Voltage protection extends to 1200 V on ac or dc and 350 V peak on ohms.

The capability of this DVM may be changed or expanded as measurement needs change. For example, a four-digit DVM may be converted to a five-digit DVM by changing display sections. Most important, this system fights obsolescence.

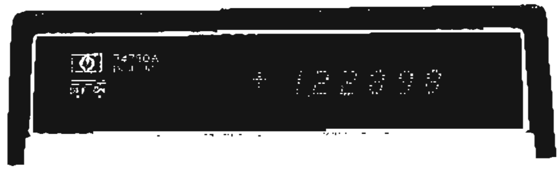
Service

Snap-out PC boards make servicing easy. Once the display PC board and voltmeter board have been removed from the case, they may be recombined. Components and test points may be reached without extender boards or special connectors. A self-test jumper in the display forces a full scale reading to act as a quick check. Accessories include the 11456A Read Out Test Card which performs a variety of tests on the display sections.



34740A Display

This four-digit display locks onto any center section or voltmeter module to form a complete DVM. It has four full digits plus 100% overranging. Price: $325.



34750A Display

This five-digit display locks onto any center section or voltmeter module to form a complete DVM. It has five full digits plus 100% overranging. Price: see data sheet.

34721A BCD Module

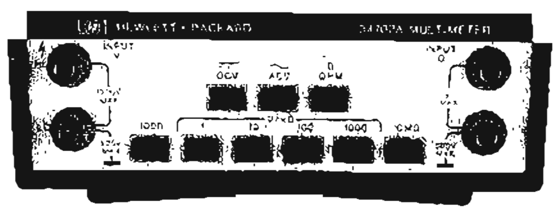
This center section provides nonisolated BCD output for operation with printers and other devices. Price: $175.

34720A Battery Module

This center section makes the 3470 into a portable DVM with six hours of continuous operation. Batteries are rechargeable. Module has side handles and front panel battery charge indicator. Price: $200.

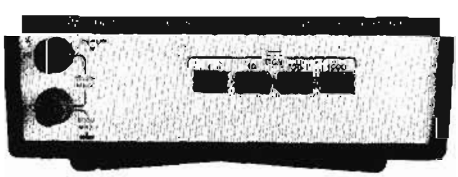
34722A Preamp/Ammeter Module

This center section provides added sensitivity (100 mV F.S. ac and dc), and ac/dc current measurement capability (100 μA to 1 A F.S.) when used with the 34702A Multimeter plug-on. Extended dc voltage and current capability can be obtained when using the 34701A DC Voltmeter plug-on. Price: available, Spring '73.



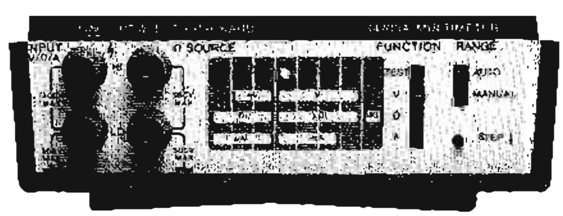
34702A Multimeter

This plug-on provides four ranges of dc and ac (1 V to 1 kV F.S.) plus six ranges of ohms (100 ohms to 10 megohms). The ac function covers 45 Hz to 100 kHz. Price, $275.



34701A DC Voltmeter Plug-on

This plug-on provides four ranges of dc from 1 V to 1 kV F S. at an economical price. Price, $150.

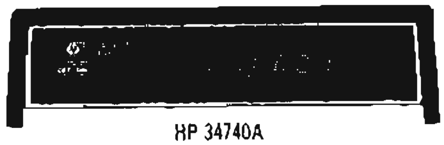


34703A DC/DCI/Ohmmeter Plug-on

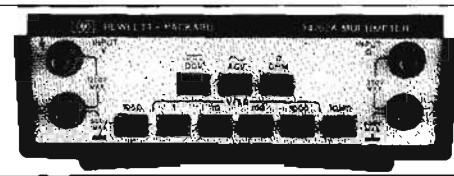
This autoranging plug-on provides six ranges of dc volts (10 mV to 1 kV F.S.), six ranges of dc current (±1 μA to ±100 mA F.S.), and eight resistance ranges (one ohm to 10 megohms).
Price: see data sheet.

HP 34701A DC Voltmeter Plug-on Tentative Specifications

For operation with either the HP 34740A, 4½ digit display, or with the HP 34750A, 5½ digit display.

	 HP 34740A	 HP 34750A
Ranges: (full scale) DC	±1 V, ±10 V, ±100 V, ±1 kV; Overrange: 100%, 20% on 1 kV range	
Maximum display:	19999	199999
Accuracy: (30 days, 23°C ±5°C)	±(0.03% of reading ±0.01% of range)	±(0.025% of reading ±0.005% of range)
Common mode rejection	>120 dB	>130 dB
Normal mode rejection	>60 dB	
Input resistance	10 MΩ ±0.1%	

HP 34702A Multimeter Tentative Specifications



Tentative Specifications	 HP 34740A Display	 HP 34750A
	DC Voltage	
DC Specifications	Same as 34701A except input resistance: 11.1 MΩ ±0.1%, 1 and 10 V range	
	AC Voltage	
Ranges (full scale) DC		
Maximum display	19999	199999
Frequency	45 Hz to 100 kHz	
Accuracy (30 days, 23°C ±5°C)	45 Hz – 20 kHz: ±(0.25% of reading ±0.05% of range) 20 kHz – 100 kHz: ±(0.75% of reading ±0.05% of range)	
	Ohms	
Ranges (full scale)	100Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ	
Accuracy (30 days, 23°C ±5°C)	10 MΩ range: ±(0.25% of reading ±0.02% of range) All other ranges: ±(0.05% of reading ±0.02% of range)	
Current through unknown	10 mA on 100Ω range decreasing one decade for each range increase	
Overload protection	±350 V peak (250 rms)	

HP 34703A DC/DCI/Ohmmeter
Tentative Specifications

For operation with either the HP 34740A, 4½ digit display, or with HP 34750A, 5½ digit display.

Tentative Specifications	 HP 34740A	 HP 34750A
	DC Voltage	
Ranges (full scale)	Auto or manual: ±10 mV, ±100 mV, ±1 V, ±10 V, ±100 V, ±1 kV	
Overranging	1000 V range: 20%. All others: 100%	
Maximum display	19999	199999 (except as noted)
Accuracy (30 days, 23°C ±5°C)	10 mV range: ±(0.03% of reading, ±0.03% of range) 100 mV and 1 V range: ±(0.03% of reading, ±0.01% of range) 10 V through 1000 V range: ±(0.04% of reading, ±0.01% of range)	10 mV range: (4½ digits displayed) ±(0.025% of range) 100 mV range and 1 V range: (5½ digits displayed) ±(0.025% of reading, ±0.005% of range) 10 V through 1000 V range (5½ digits displayed) ±(0.035% of reading, ±0.005% of range)
Input resistance	10 MΩ ±0.1%	
Common mode rejection	>120 dB	
Normal mode rejection	>60 dB	
	DC Current	
Ranges (full scale)	Auto or manual selection of: ±1 μA, ±10 μA, ±100 μA, ±1 mA, ±10 mA, ±100 mA	
Overranging		
Maximum display	19999	19999 (5th digit blanked)
Input resistance		
Accuracy (30 days, 23°C ±5°C)	1 μA and 10 μA range: ±(0.04% of reading, 0.03% of range) 100 μA and 1 mA range: ±(0.06% of reading, ±0.03% of range) 10 mA and 100 mA range: ±(0.25% of reading, ±0.03% of range)	1 μA and 10 μA range: ±(0.035% of reading, ±0.025% of range) 100 μA and 1 mA range: ±(0.055% of reading, ±0.065% of range) 10 mA and 100 mA range: ±(0.25% of reading, ±0.025% of range)
	Ohms	
Ranges (full scale)	Auto or manual selection of: 1Ω, 10Ω, 100Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ	
Overrange	100% on all ranges	
Maximum display	19999	199999 (except on 1Ω range)
Conversion method	4-wire measurement	
Accuracy (30 days, 23°C ±5°C)	1Ω range: ±(0.04% of reading, ±0.03% of range) 10Ω through 1 mΩ ranges: ±(0.04% of reading, ±0.01% of range) 10 mΩ range: ±(0.12% of reading, ±0.01% of range)	1Ω range: (4 digits only) ±(0.035% of reading, ±0.025% of range) 10Ω through 1 mΩ ranges: ±(0.035% of reading, ±0.005% of range) 10 MΩ range: ±(0.12% of reading, ±0.005% of range)

Snap together expandability

34720A Battery Module

Description

This center section provides six hours of continuous battery operation. The batteries used in the 34720A are a resealable vented nickel cadmium type with a 40 watt-hour capacity. A front panel pushbutton and associated meter indicate the charge condition.

34721A BCD Module

Description

This center section adds nonisolated BCD output to the 3470 Measurement System. This section couples the 3470 to other devices such as a printer. A variable sample rate control from zero to four readings per second is provided on the front panel. In the HOLD position, internal samples are stopped so that external triggers may be used. A manual pushbutton trigger is also provided for single samples.

Output levels are TTL compatible. Information is coded in an 8-4-2-1 sequence. Up to six columns are used for the reading. Additional columns are used for functions, range and polarity. This center section may be used with either the four-digit 34740A display or the five-digit 34750A display.

34722A Preamp/Ammeter (available, Spring '73)*

Used with 34701A DC Voltmeter or 34702A Multimeter and 34740A or 34750A Display.

Preamplifier: X10 Gain for ac and dc. (e.g., 100 mV F.S. sensitivity.)

Current mode: ac and dc from 100 μA to 1 A F.S., 100% overranging. Full scale insertion loss: 100 mV.

*Refer to data sheet for specifications.

General

Power: 110/120/220/240 V −10%, +5% switchable; 48 Hz to 440 Hz; ≤8.7 VA.

Dimensions: (with two snap-on modules: 3½" high; with three: 5¼" high), 6¼" wide, 9¾" deep, (89 or 133.35 mm x 160 mm x 248 mm).

Weights

	Net	Shipping
34740A Display	3 lbs (1,36 kg)	4 lbs 4 oz (1,99 kg)
34750A Display	3 lbs (1,36 kg)	4 lbs 4 oz (1,99 kg)
34701A DC Voltmeter	2 lbs (0,9 kg)	3 lbs 4 oz (1,53 kg)
34702A Multimeter	2 lbs (0,9 kg)	3 lbs 4 oz (1,53 kg)
34703A DC/DCI/Ohmmeter	2 lbs (0,9 kg)	3 lbs 4 oz (1,53 kg)
34720A Battery Module	5 lbs (2,26 kg)	6 lbs 4 oz (2,89 kg)
34721A BCD Module	1 lb 8 oz (0,82 kg)	2 lbs 12 oz (0,95 kg)
34722A Preamp/Ammeter	1 lb 8 oz (0,82 kg)	2 lbs 12 oz (0,95 kg)

Operating temperature: 0°C to +50°C.

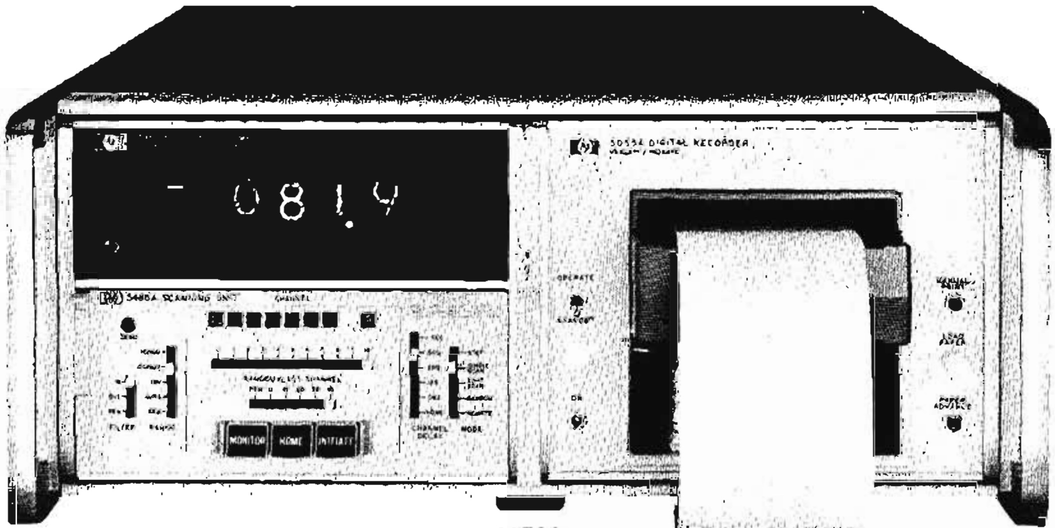
Storage temperature: −40°C to +75°C.

Accessories available

- 11456A Readout Test Card for testing and troubleshooting the 34740A Display, $50.
- 18019A Carrying Case accommodates the 34740A Display, a center section and a bottom section plus power cord and input cables, $25.
- 11457A Rack Mount Kit for 34740A Display, 34721A BCD Module and one bottom section, $35.
- 562A-16C Printer Cable for operation with 5055A Digital Recorders, $60.

Prices: see page 78.

DATA LOGGER
Portable data acquisition system
Model 2070A



2070A

Description

The 2070A Data Logger is a complete data acquisition system able to scan up to 50 two-wire inputs with the 3485A Scanning Unit. With the sample-and-hold option, it is able to digitize low frequency wave shapes. With the data storage option, up to 1000 readings/s can be taken.

The 2070A Data Logger combines a 3480A one-half module DVM with a 5055A one-half module line printer. Both units are combined in a portable fan cooled case. When the 2070A is equipped with Data Storage (Option 005), a special rear panel includes controls to select the number of channels stored and the mode of operation.

3480A Digital Voltmeter

One-half module 3480A equipped with Option 004, Isolated BCD. Options include Sample-and-Hold (Option 001) and Data Storage (Option 005). Any one of the three 3480 plug-ins may be ordered optionally with the 2070A. See pages 83-86.

5055A Digital Recorder

One-half module, 10 column line printer. Printing rate up to 10 lines/s. Accepts ink roller or pressure sensitive paper. Paper used is "Z" fold. Front panel light controls include a power switch, a standby/operate switch, a paper advance button and a manual print button. See page 242.

Specifications, 2070A Rear Panel Controls

Standard

Line switch: for both 3480A and 5055A.

External trigger: BNC connector brings out Measure line from 3480A.

Trigger mode switch: local mode allows front panel sample rate control to be used. External mode disables front panel Sample rate control.

Option 005, Data Storage (stores up to 50 complete readings)
All standard controls plus

Storage limit: five position rotary switch to select Storage limit, (10, 20, 30, 40 or 50 readings).

Scanner enable switch: for operation with 3485A. Allows a nonmultiple of 10 channels to be scanned, stored and printed.

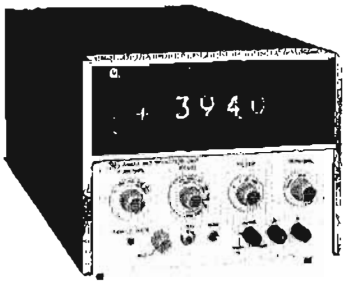
Storage enable switch: turn Data Storage on, otherwise, it acts like Isolated BCD output.

14 pin connector: brings out major Data Storage control lines.

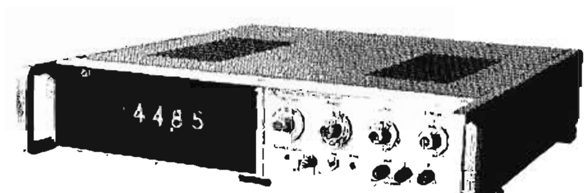
2070A Data Logger

Includes 3480A Option 004 and 5055A Digital Recorder in fan cooled combining case	$2770
Option 001 Sample-and-Hold	add $ 500
Option 005 Data Storage	add $1000
Option 082 3485A DC Range Unit	add $ 755
Option 842 3484A Multifunction Unit with dc and ohms	add $1185
Option 843 3484A Multifunction Unit with ac and dc	add $1895
Option 844 3484A Multifunction Unit with ac/dc/ohms	add $2095
Option 851 3485A Scanning Unit with 10 channels	add $1400
Option 852 3485A Scanning Unit with 20 channels	add $1500
Option 853 3485A Scanning Unit with 30 channels	add $1600
Option 854 3485A Scanning Unit with 40 channels	add $1700
Option 855 3485A Scanning Unit with 50 channels	add $1800
Option 857 Isolated Remote Control for the 3485A	add $ 300

DIGITAL VOLTMETER
Multi-function DVM for bench and system use
Models 3480A and 3480B



3480A



3480B

Description

The 3480A/B Digital Voltmeter covers a variety of systems and bench applications. The four-digit mainframe has 50% overranging which is available in two sizes, the one-half module 3480A or the full rack width, 3480B. These mainframes may accommodate any of three signal conditioning plug-ins. The 3482A plug-in has five dc ranges; the 3484A has five dc ranges, five true rms ac ranges and six ohms ranges; and the 3485A has up to 50 two-wire dc input channels.

Mainframe options further enhance the flexibility of the 3480. To digitize changing voltages at rates up to 1000 readings/s, Option 001 Sample-and-Hold is available. The instantaneous value of the input signal is held during A-to-D conversion. Two BCD output options are available: Option 003 Non-isolated BCD and Option 004 Isolated BCD. Up to 50 readings may be stored at 1000/s for output at a lower speed (i.e., on a line printer) using Option 005 Data Storage.

The 3480 may be purchased as part of a portable data acquisition system, the 2070A Data Logger. The 2070A combines a 3480A DVM with a 5055A Digital Recorder.

Output Options

The 3480A or B may be equipped with one of three output options. All of these options are designed to transmit digital information from the DVM to external devices such as printers, tape punches, couplers, computers, calculators, etc. Information transmitted consists of the reading, polarity, range, function and overload. In the case of the 3485A Scanning Unit, two-digits of Channel I.D. are also transmitted.

Non-isolated BCD (Option 003) may be factory or field installed and has its ground line connected directly to the input Low terminal on the front panel. Floating measurements may not be made into a grounded system with this option. This option may not be used with the 3485A Scanning Unit.

Isolated BCD (Option 004) is a factory installed option which isolates the input Low terminal from the ground used on the output lines.

Data Storage (Option 005) is a factory installed option which includes isolated BCD output. Up to 50 complete DVM readings may be entered into Data Storage at up to 1000/s. The output rate of these stored readings is governed by an external device such as a printer. This allows readings to be taken at high speed, stored, then outputted at 10 to 20 lines per second.

The Sample-and-Hold (Option 001) allows the 3480 to be used to economically digitize low frequency wave forms. Precision four-digit measurements are possible on a changing input voltage at reading rates up to 1000/s.

Sample-and-Hold is physically located in the 3480's mainframe. The input voltage is tracked until a trigger is given, then Sample-and-Hold freezes the input voltage and holds it for 1 ms, the digitizing period of the 3480. After digitization, tracking resumes automatically.

Sample-and-Hold may be triggered to instantly freeze the input voltage. A delay of 105 μs may be added to allow for settling time of the input amplifier. The delay is used for measuring pulse amplitude where there is a full scale step input.

Specifications

Performance

Acquisition time: time to respond to a plus or minus full scale step input to within ±0.01% of final value.

Plug-in unit

Range	3482A	3484A	3485A
±100.00 mV	100 μs	100 μs	100 μs
±1000.0 mV	70 μs	70 μs	70 μs
±10.000 V	70 μs	70 μs	50 μs
±100.00 V	70 μs	70 μs	–
±1000.0 V	70 μs	70 μs	–

Maximum dV/dT: 8% of range/μs, Sample-and-Hold enabled.

Aperture time: time from command to the Sample-and-Hold option to take a reading to when the signal is actually held: 110 ns ±20 ns.

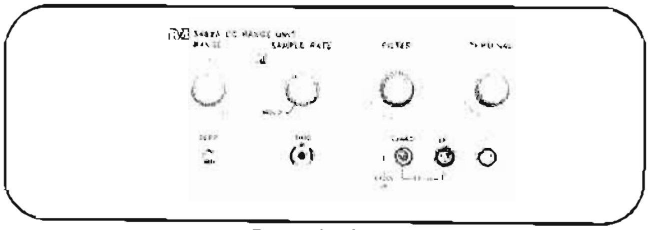
A delay of 105 μs ±10 μs may be added prior to aperature time by using Delay On or by triggering through Measure (normal trigger).

General

Accessories available: see data sheet.
Operating temperature: 0°C to 55°C.
Power: 115 V or 230 V ±10%; 40 Hz to 440 Hz, 60 VA max, including any plug-ins or options.
Dimensions
3480A: 8" wide, 6-3/32" high, 16" deep (203.2 x 154,8 x 406,4 mm). (Half-rack width module.)
3480B: 16⅝" wide, 3⅜" high, 18⅜" deep (422,8 x 85,7 x 466,7). (Rack width module.)
Weights
3480A: net, 12 lbs 8 oz (5,7 kg); shipping, 17 lbs (7,65 kg).
3480B: net, 13 lbs 8 oz (6,15 kg); shipping, 18 lbs (8,1 kg).
Prices
3480A One-half module mainframe, $895.
3480B Full rack width mainframe, $995.
Mainframe Options
Option 001 Sample-and-Hold, $500.
Option 003 Digital Output, $200.
Option 004* Isolated Digital Output, $375.
Option 005* Data Storage, $1000.

*Must be ordered for use with Option 021, 041, or 057.

3482A DC Range Unit



Description

The 3482A has five dc voltage ranges selectable manually, automatically or remotely. The 3482A has guarded floating inputs with switchable front and rear terminals. Triggering may be done internally at rates from 1/s to 25/s using a front panel control. Triggers may also be issued manually or remotely. A three-position input filter provides selectable degrees of normal-mode noise rejection. Isolated Remote Control, Option 021 adds remote control over filter and range.

Specifications, 3482A DC Range Unit

DC voltages

Ranges
Full range display: ±100.00 mV, ±1000.0 mV, ±10.000 V, ±100.00 V and ±1000.0 V.
Overrange: 50% on all but 1000 V range, ±1200 V max input.
Range selection: manual, automatic or remote.
Automatic ranging: upranges at 140% of range; downranges at 10% of range.

Performance

Accuracy: (90 days, 25°C ±5°C, <95% RH).
100 mV range: ±(0.01% of reading +0.02% of range).
All other ranges: ±(0.01% of reading +0.01 of range).
Measuring speed
Response time
Filter Out: 1 ms. Reads to within 1 count of final reading when triggered coincident with application of step input voltage.
Filter A: 200 ms to within 1 count of final reading.
Filter B: 1 s to within 1 count of final reading.
Reading period: 950 μs.
Reading rate (without range change)
Manual: reading may be manually initiated with front panel pushbutton.
Internal: 1 to 25 per s with front panel control.
External: 0 to 1000 per s with external trigger.

Input characteristics

Input resistance
100 mV, 1000 mV, 10 V ranges: $>10^{10}\Omega$.
100 V, 1000 V ranges: 10 MΩ ±0.1%.
Common mode rejection: >80 dB, dc to 60 Hz (1 kΩ in either lead).
Normal Mode Rejection (NMR)

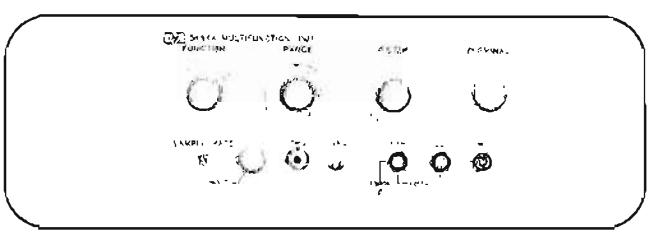
Filter Position	50 Hz	60 Hz and above
Out	0 dB	0 dB
A	>27 dB	>30 dB
B	>77 dB	>80 dB

Filter selection: manual or remote.
Noise: <40 μV peak to peak (unfiltered). Peak to peak noise is <40 μV 95% of the time since the noise amplitude approximates a Gaussian distribution where the standard deviation (which is also the rms value) = 10 μV.
Maximum input voltage
Guard to Chassis: ±500 V peak.
Guard to Low: ±200 V peak.
High to Low: ±1200 V peak.

General

Weight: net, 4 lbs 4 oz (1,9 kg); shipping, 7 lbs (3,15 kg).
Price: Hp 3482A, $755; Option 021, $200.

3484A Multifunction Unit



Description

The 3484A offers the same dc capability as the 3482A dc range unit with the addition of five true rms ac ranges and six ohms ranges. The true rms ac converter eliminates serious errors caused by small amounts of distortion on the input signal, and also extends measurement capability to the measurement of non-sinusoids. A dc coupled mode allows the direct measurement of both the ac and dc components of the input signal. Frequency range extends from 1 Hz to 10 MHz. The ohms converter covers from 100.00 ohms to 10.000 megohm full scale. Remote selection of range, function and filter position is possible with Isolated Remote Control, Option 041.

Specifications, 3484A Multifunction Unit

DC voltage

Same specifications as 3482A DC Range Unit.

Ohms, Option 042

Ranges
Full range display: 100.00Ω, 1000.0Ω, 10.000 kΩ, 100.00 kΩ, 1000.0 kΩ, and 10.000 MΩ.
Overrange: 50% on all ranges.
Range selection: manual, automatic or remote.

Automatic ranging: upranges at 140% of range; downranges at 10% of range.

Performance

Accuracy: (90 days, 25°C ±5°C, <95% RH).

1000Ω thru 1000 kΩ ranges: ±(0.01% of reading +0.01% of range).

100Ω range: ±(0.02% of reading +0.05% of range).

10 MΩ range: ±(0.1% of reading +0.01% of range).

Measuring speed

Response time

100Ω thru 100 kΩ ranges (no filtering): 1 ms. Reads to within 1 count of final reading when triggered coincident with application of input.

1000 kΩ range (Filter A): 200 ms to within 1 count of final reading.

10 MΩ range (Filter A): 2s to within 1 count of final reading.

Reading period: 950 μs.

Reading rate (without range change)

Manual: reading may be manually initiated with front panel pushbutton.

Internal: 1 to 25 s with front panel control.

External: 0 to 1000/s with external trigger.

Input characteristics

Voltage across unknown: 1 V at full scale, all ranges.

Current thru unknown

100Ω range: 10 mA.

1000Ω range: 1 mA.

10 kΩ range: 100 μA.

100 kΩ range: 10 μA.

1000 kΩ range: 1 μA.

10 MΩ range: 100 nA.

Overload protection: ±75 V peak maximum input, all ranges.

True RMS AC Voltage Option 043

Ranges

Full range display: 100.00 mV, 1000.0 mV, 10.000 V, 100.00 V, and 1000.0 V.

Overrange: 50% on all ranges, 1500 V peak max input.

Range selection: manual, automatic or remote.

Automatic ranging: upranges at 140% of range; downranges at 10% of range.

Performance

Accuracy: (90 days, 25°C ±5°C, 95% RH).

DC: ±1.0% of reading, 60% to 150% of range. For voltages below 60% of range, the "Accuracy Multiplier" must be used.

AC: as specified by graphs.

Response

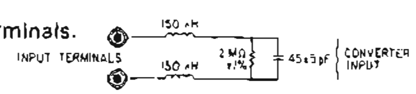
VAC (AC) function: responds to true rms value of ac coupled input signal.

VAC (DC) function: responds to true rms value of dc and ac input signal. Reading is $\sqrt{(dc)^2 + (ac\ rms)^2}$. An external 10 μF coupling capacitor may be used to eliminate the dc component and measure ac component only from 1 Hz to 10 MHz.

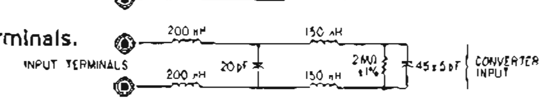
Function selection: manual or remote.

Input impedance

Front terminals.



Rear terminals.



*For readings below 60% of range, use the "Accuracy Multiplier" graph times the basic accuracy. For example a 1 kHz, 30 mV signal would have an accuracy of ±0.1% times 2 or ±0.2% on the 100 mV range.

Crest factor: 7:1 at full scale, derated linearly from 35 Hz to 2.2:1 at 5 Hz.

Maximum input voltage

VAC (DC): 1500 V peak ac, 100 V dc, (10 V dc max on 100 mV range); dc + ac = 1500 V max.

VAC (DC): 1000 V rms; dc + ac = 1500 V max.

Measuring speed

Response time (without range change).

VAC (AC): 1 s to within 10 counts of final reading (*input change from 10% to 100% of range*) or 20 counts of final reading (input change from 100% to 10% of range).

VAC (DC): 15 s to within 10 counts of final reading.

Reading rate

Manual: reading may be manually initiated with front panel pushbutton.

Internal: 1 to 25 per s with front panel control.

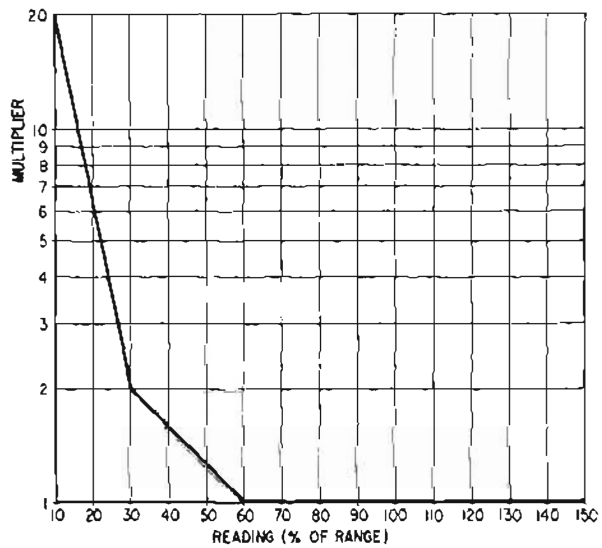
External: 0 to 1000/s with external trigger.

Accuracy Multiplier

VAC (AC) and VAC (DC) functions, all ranges, for reading below 60% of range.

ACCURACY MULTIPLIER

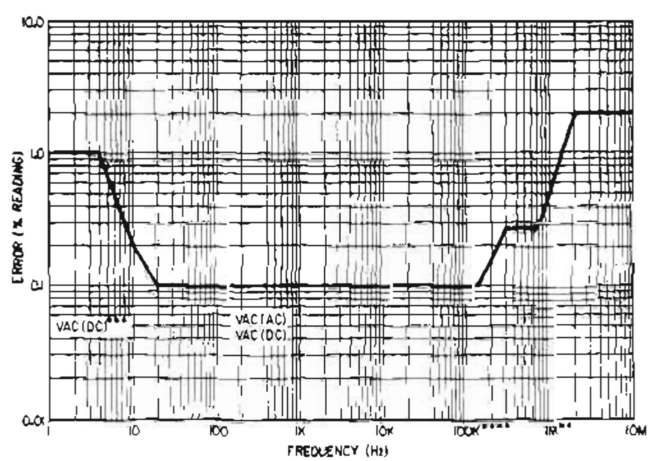
VAC (AC) AND VAC (DC) FUNCTIONS ALL RANGES. FOR READINGS BELOW 60% OF RANGE



**Accuracy, for frequencies >1 MHz, is only specified from the front terminals.

100 mV AND 1000 mV RANGES

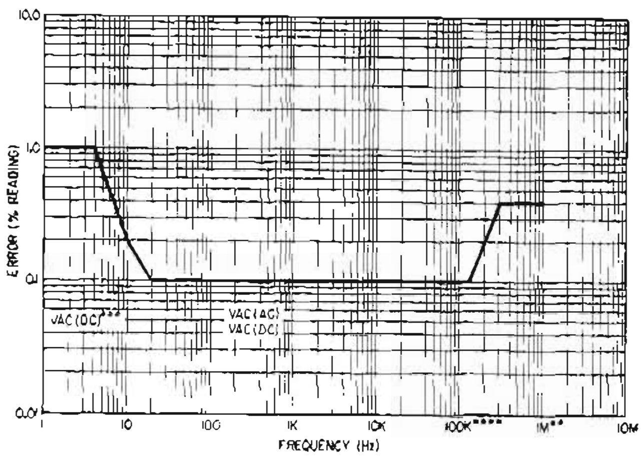
CONDITIONS 90 DAYS 25°C ±5°C, <95% RH, 60% TO 150% OF RANGE * <10⁷ VOLT-Hz



***Instrument reading is $\sqrt{(dc)^2 + (ac\ rms)^2}$. An external 10 μF coupling capacitor may be used to eliminate the dc component and measure the ac component only from 1 Hz to 10 MHz in VAC (DC).

10 V, 100 V AND 1000 V RANGES

CONDITIONS 90 DAYS, 25°C ±5°C, <95% RH, 60% TO 150% OF RANGE,* <10⁸ VOLT–Hz.

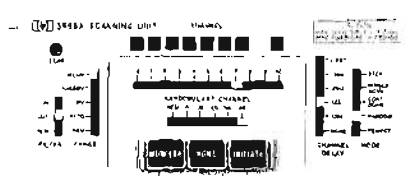


****The 1000 V range is not specified for frequencies >100 kHz.

General

Weight: net, 6 lbs 2 oz (2,75 kg); shipping, 8 lbs (3,6 kg).
Price: HP 3484A, $970.
Option 041 Isolated Remote Control, $200.
Option 042 Ohms Converter, $200.
Option 043 True RMS AC Converter, $900.

3485A Scanning Unit



3485A

Description

The 3485A is a dc Scanning Unit with up to 50 two-wire floating inputs and three dc voltage ranges from 100.00 mV to 1000.0 V full scale. By using FET switches, scan rates up to 1000 channels/s are possible. Scan modes include step, single scan, continuous scan and random. The dwell time on each channel may be varied in six steps from one second to "none". Input resistance is $>10^{7}\Omega$. Autoranging is standard and the 3485A has a switchable 30 dB filter. Isolated Remote Control, Option 057 allows remote control over ranges, filter, scanning modes and random or last channel.

Specifications, 3485A Scanning Unit

Channels

Number: up to 50 channels which may be purchased in increments of 10 channels.
Input configuration: floating FET switches with separate Guard for every block of 10 channels.

Ranges

±100.00 mV, ±1000.0 mV, and ±10.000 V.

Overrange: 50% on all ranges, ±50 V max input.
Range selection: manual, automatic, or remote.
Automatic ranging: upranges 140% of range; downranges at 10% of range.
Time required: 1.5 ms per range change.

Performance

Accuracy (90 days, 25°C, <95% RH)
100 mV range: ±(0.01% of reading +0.04% of range).
1000 mV and 10 V ranges: ±(0.01% of reading +0.01% of range).

Maximum operational voltage (for rated accuracy)

High to Low: ±15 V dc.
Guard to Chassis: ±50 V peak.
Guard to Low: ±10 V peak.
The algebraic sum of all voltages in a path between any Low to any High must not exceed ±15 V peak.
The maximum algebraic voltage difference between any Low to any other Low must not exceed ±15 V peak.

Maximum input voltage

High to Low: ±50 V peak.
Guard to Chassis: ±50 V peak.
Guard to Low: ±50 V peak.

Measuring speed

Response time
Filter Out: 1 ms to read within 1 count of final reading when triggered coincident with application of step input.
Filter In: 250 ms to read within 1 count of final reading.
Reading period (including response time and digitizing time): 950 μs.
Scanning and reading rate
Manual: readings may be manually initiated on any one channel with a front panel self-latching pushbutton (Monitor) at a fixed three reading per second.
Internal: readings may be automatically initiated in the Single Scan or Continuous Scan modes at any one of six selected Channel Delays. Speed varies from 1 channel per second to 1000 channels per second. With Filter In, a minimum delay of 250 ns is used.
External: 0 to 1000 channels per second with external trigger.
Channel Delay: six delays; 1 s, 500 ms, 250 ms, 125 ms, 62 ms, and "NONE". In "NONE", there is no dwell time on a given channel and the speed is limited mainly by the reading period (1 ms). The reading is taken after the selected Channel Delay.

Input characteristics

Input resistance (25°C, <95% RH): $>10^{7}\Omega$.
Effective Common Mode Rejection (ECMR)
DC: >80 dB.
AC (50-60 Hz)
Filter Out: >76 dB.
Filter In: >105 dB.
Normal Mode Rejection (NMR)

Filter Position	60 Hz	60 Hz and above
Out	0 dB	0 dB
In	>27 dB	>30 dB

Filter selection: manual or remote.

General

Weight: net, 7 lbs 3 oz (3.2 kg); shipping, 8 lbs 14 oz (4 kg).

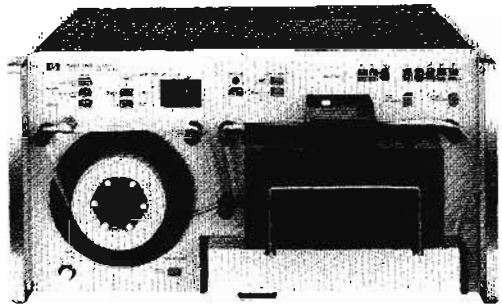
Prices: HP 3485A, $1400.
Option 051 10 channels, $100.
Option 052 20 channels, $200.
Option 053 30 channels, $300.
Option 054 40 channels, $400.
Option 055 50 channels, $500.
Option 057 Isolated Remote Control, $300.

DATA COUPLER/DATA PUNCH

Punches popular tape codes from DVM's

Model 3489A

NEW▶



3489A

Description

Hewlett-Packard's 3489A Data Punch is a combination coupler and paper tape punch. Features include an internal timer for unattended data logging and a data counter to add line numbers. Output format from the 3489A is controlled by a pin-board so that any popular paper tape code may be punched, such as ASCII, EBCDIC, BCD or CCITT. Special characters may be added to construct special formats. Length of data words may be varied to 30 characters. Number of readings per line is variable.

Features

BCD Input

The 3489A accepts up to eight BCD digits of measurement data plus one BCD digit for range, one BCD digit for function and one BCD digit for polarity and overload.

Programmable output codes

The character code for the punched tape can be programmed to be compatible with virtually all computer, telex and calculator systems.

Programmable data formatting

Up to 10 special characters can be programmed for data formatting on the punched tape.

Internal timer

The data punch can be set to sample a measurement at intervals from one to 99 seconds or minutes.

Data counter

Internal data counter automatically adds a four-digit I.D. to each reading. This number may be used as line numbers or simply to identify readings.

Manual punching

Front panel pushbuttons can be used to punch identification characters on the tape.

Specifications

Punching speed: 70 characters/s.

Punched tape format: any code up to 8 bits can be programmed. Special characters can be programmed for data formatting.

Tape widths: accepts all standard widths.

Type of tape: paper, oiled paper, mylar or metallized mylar.

Tape supply: 300 meters (1000 ft) standard reel.

Tape winder capacity: 80 meters (260 ft) equivalent to 32,000 characters.

Punching tolerance: in accordance with the following standards. ISO/TC 97 (Secr-146)221; BS 3800:1965; DIN 66106.

Interface lines

Data: TTL compatible, positive "true", BCD coded 8-4-2-1. Up to 8 digits of measurement data. One digit for range, one digit for function, one digit for polarity and overload.

Punch (print) command: voltage step from high level to low level. TTL compatible.

Hold-off signal: high level or low level for hold-off—selected by jumper. Active during punch operation or, when in DATA RATE INT mode, between sample times. TTL compatible.

General

Operating temperature: +8°C to +40°C.

Humidity: 0 to 95% RH over full temperature range.

Weight: shipping 52 lbs (23 kg).

Dimensions: 425 mm wide, 230 mm high and 533 mm deep (16¾" x 9-1/32" x 21").

Power:

Option 050: 230 V ±10%, 50 Hz.

Option 060: 115 V ±10%, 60 Hz.

145 VA tape winder on, 110 VA tape winder off.

Options

Option 001 Bypass Card: this card allows up to 8-bit parallel characters from an external device (e.g., computer) to be punched directly. The data and hold-off (busy) signals can be selected by jumper to be negative "true" or positive "true." The punch (print) command is provided by the external device and can be selected, by jumper, to be a positive or negative going edge.

Option 002 Time Input Card: this card accepts up to six BCD digits of time information. Data signals can be selected, by jumper, to be positive or negative "true". A maximum of six special characters can be programmed for data formatting purposes. The card can be disabled by a rear panel switch or by a remote signal.

Prices

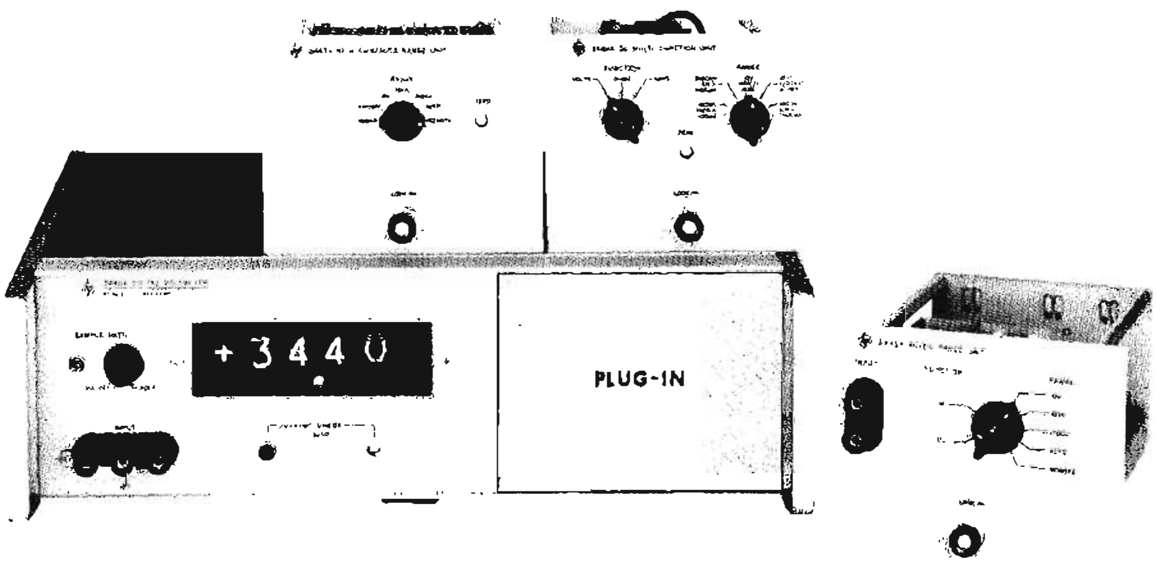
3489A Data Punch, $3000; Option 050, 230 V/50 Hz, N.C.; Option 060, 115 V/60 Hz, N.C.; Option 001, (11460A) Bypass Input Card, $170; Option 002, (11461A) Time Input Card, $220.

11462A Cable, 3480/85A, $60; 11463A Cable, 3480/82A/84A, $60; 11464A Cable, 3480/Opt 005/85A, $60; 11465A Cable, 5326/5327A/B/C, $60; 11466A Cable, Open-ended, $45; 11467A Cable, 3490A, $60; 5060-8317 (02116-6178) Connector Kit, $10; (one supplied with instrument); 11468A Adapter Box, $85; 11469A Test Card, $200; 5060-1742 Extender Board, $23; 5060-8741 Rack Mount Kit, $8.

DIGITAL VOLTMETERS

Interchangeable plug-ins provide versatility

Models 3440A, 3443A, 3444A and 3445A



3440A

Description

The Hewlett-Packard 3440A and its associated plug-ins are designed for general purpose measurements of dc volts, ac volts, dc current and ohms. The 3440A has BCD output for use with printers and other devices. The normal output code is 1-2-2-4. A 1-2-4-8 output code is available on the 3440A Option H02. The sample rate on the 3440A is adjustable on the front panel at up to five readings per second.

The 3440A will accept any of three plug-ins. The 3443A offers five dc voltage ranges. The 3444A has five dc voltage ranges plus dc current and ohms. The 3445A has three ranges of both ac and dc volts.

The accuracy of the 3440A is dependent on a highly stable zener diode reference. Accuracy is verified, anytime during operation, by pressing a front panel button and adjusting the reading to equal the reference voltage. The internal calibration source will stay within ±0.05% for three months, and has a TC of ±0.002%/°C.

The 3440A has four full digits or a maximum display of "9999". An additional five percent overranging is indicated by an overrange light. Rated accuracy is maintained in overrange.

The input terminals may be floated up to 500 V dc. The dc input resistance is a constant 10.2 MΩ. The ac input impedance is 10 MΩ shunted by 20 pF. Separate input terminals help reduce shunt capacity.

Specifications

Plug-in capability chart

DC Volts	3443A	3444A	3445A
100 mV and 1 V	●	●	
10 V, 100 V and 1000 V	●	●	
AC Volts 10 V, 100 V and 1000 V			●
Ohms 1 kΩ through 10 MΩ		●	
DC Current 100 μA through 1 A		●	
Autoranging	●		●
Remote Ranging	●		●

DC VOLTAGE	3443A	3444A	3445A
Ranges	±100 mV, ±1 V, ±10 V, ±100 V and ±1000 V		±10 V, ±100 V and ±1000 V
Overrange	5%		
Accuracy 25°C ±5°C for 30 days after calibration against in-reference	100 mV and 1 V ranges: ±(0.1% of reading +0.01% of range) 10 V through 1000 V: ±(0.05% of reading +0.01% of range)		±(0.05% of reading +0.01% of range)
Input Resistance	10.2 MΩ		
Range Selection	Manual, automatic or remote	Manual	Manual, automatic or remote

AC VOLTAGE			3445A
Ranges			10 V, 100 V and 1000 V
Frequency Range			50 Hz to 100 kHz
Accuracy 50 Hz to 20 kHz 20 kHz to 50 kHz 50 kHz to 100 kHz			±(0.1% range +0.02 reading) ±0.12% of reading ±0.1% to ±0.3% of range linearity derated with frequency
Input Impedance			10 MΩ//20 pF
Response Time			3s
Range Selection			Manual, automatic or remote

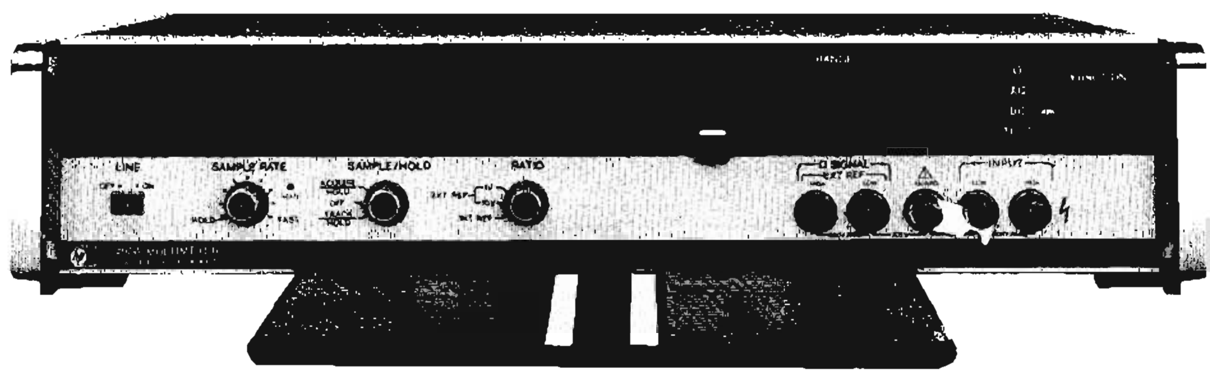
OHMS		3444A	3445A
Ranges		1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ and 10 MΩ	
Accuracy 1 kΩ through 1 MΩ 10 MΩ		±(0.3% reading +0.01% range) ±(1% reading +0.01% range)	
Response Time		1 s except 10 MΩ range where it is 5 s	
Range Selection		Manual	

DC CURRENT		3444A	
Ranges		±100 μA, ±1000 μA, ±10 mA, ±100 mA, and 1 A	
Accuracy		±(0.2% reading +0.01% range)	
Range Selection		Manual	

GENERAL	3443A	3444A	3445A
Weight	Net: 3 lbs (1,35 kg) Ship: 5 lbs (2,3 kg)		Net: 2.75 lbs (1,24 kg) Ship: 5 lbs (2,3 kg)
3440A Mainframe		Net: 18 lbs (8 kg); Ship: 29 lbs (13 kg)	
Price	$565 (H02, $590)*	$655 (H02, $680)*	$655 (H02, $680)*
3440A Mainframe*	$1400 (H02, $1500)*		

*Option H02 offers 1-2-4-8 output code; 1-2-2-4 output code is standard.

DIGITAL MULTIMETER
Five-digit DMM with unique self-test
Model 3490A



3490A

NEW

Description

The Hewlett-Packard Model 3490A Multimeter is a five digit integrating digital voltmeter. The basic instrument measures dc voltages, ac voltages, and resistances. Additional measurement capability is achieved by the addition of low cost options.

The 3490A uses a dual slope integrating technique and is fully guarded, providing excellent noise immunity at five readings per second on all dc ranges. Ranging is automatic over all ranges on all functions. DC measurements can be made with 1 μV resolution on the 100 mV range. AC voltage measurements can be made from 20 Hz to 250 kHz in four ranges. The 1 V range provides 10 μV of ac voltage resolution. Ohms measurements can be made, utilizing the four-wire conversion technique which eliminates errors due to test lead resistances. Six ranges of ohms, including a 100 Ω range, are provided. All functions and ranges include 20% overranging except the 1000 V range.

Display

The 3490A uses Hewlett-Packard's light emitting diodes (LED's). These display digits are of the dot matrix type to reduce the ambiguity caused by the failure of a single diode. The extremely high reliability of this LED display assures maximum life.

Self-test

At the flip of a switch, Hewlett-Packard's 3490A Digital Multimeter sequences itself through 10 tests that checks timing signals and autoranging circuits, validates the performance of most logic-circuit IC's and checks the six-digit LED display. These tests, and six others provided by six additional front-panel switches, cut calibrations costs and time, reduce the number of external standards required, and assure a user that his DMM is ready to make accurate measurements.

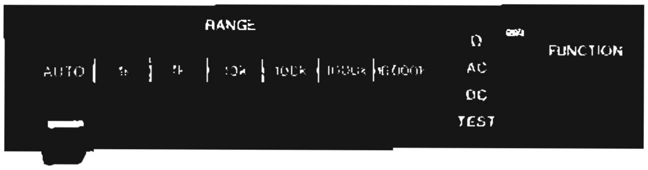
Functions

(IN DC)

The standard 3490A includes five ranges of dc measurement capability from 100 mV to 1000 V. Measurements are made from the front panel at a precise five reading/s; and at slower rates, using digitally controlled sample rate selector. High input resistance, $>10^{10}\Omega$ on 100 mV, 1 V, and 10 V range, assures accurate measurement of high impedance sources.

(IN AC)

Four ranges of ac measurements are provided. The average ac value is accurately detected, and the rms value is displayed with five digits of resolution. Full autoranging, wide frequency response, and 20% overranging are designed-in features to permit easy operation.



(IN OHMS)

Six ohms ranges are standard, and all of the ranges provide true four-wire ohms measurement capability. Maximum current through the unknown is approximately 1 mA. Over-voltage protection for the ohms sensing terminals insure maximum protection against an inadvertent application of a high voltage to ohms terminals. Over-voltage protection is provided to 250 V and fuse protection to 1000 V.

Serviceability

The 3490A has been "designed for serviceability". Inside, the 3490's low parts density provides easy access for servicing. Test points and jumpers are keyed to detailed diagnostics.

Several diagnostic aids are available to further minimize 3490A repair time. A service video tape, Accessory No. 11128A, will demonstrate use of self-test and front panel symptoms to isolate failures. The 11126A accessory provides a set of IC reference boards with most of the 3490A logic IC's for use with the -hp- 10529A Logic Comparator. Using these boards with the Logic Comparator, a faulty IC can be isolated in seconds without removing it from the circuit. Also, a spare parts set, Accessory No. 11127A, containing most critical components of the 3490A will be available to users.

Options

Systems applications

The Model 3490A offers built-in flexibility for systems applications. The 3490A offers both an ASCII character serial interface and a Bit parallel (BCD coded) interface. This combination provides the necessary versatility to configure the lowest cost instrument system.

Ratio (Opt 080)

DC/DC and AC/DC three-wire ratio measurements can be conveniently added to the 3490A. This capability offers both auto-polarity and a selection of two reference ranges. The 1 and 10 V ranges are specified from 10% to 120% of selected range. Ratio function is not programmable.

50 Hz Operation (Opt 050)
60 Hz Operation (Opt 060)

Maximum noise immunity is achieved when the power line frequency is harmonically related to the sample period of the integrating DMM. Option 050 will maximize normal and common mode rejection for 50 Hz power line frequency, and Option 060 will provide this rejection for 60 Hz.

Sample/Hold (Option 040)

Sample/Hold provides the 3490A with extra and unique measurement capability.

The Sample/Hold option has two modes of operation to solve your difficult measurement problems.

Track and Hold: in this mode the input voltage is held instantly upon receiving an external command. This mode is useful in the digitization of repetitive or transient waveforms.

Acquire and Hold: in this mode a well known delay is inserted to permit the input amplifier to settle to a specified accuracy. This is useful in measuring pulse height or any similar step input.

Digital Output (Opt 021) and Remote Control (Opt 022)

These options provide digital control and data output in the parallel BCD code of 8-4-2-1 either negative or positive true logic. Selection is accomplished by positioning an internal switch. The remote control option provides complete control of all functions, ranges, and external trigger commands. The digital output option provides nine columns of information which includes function, polarity, data, and range. These options may be purchased separately to meet specific application requirements. Either of these options require Option 020, Systems Expand.

Systems Expand (Opt 020)

This option provides the appropriate internal and external connector to install either Digital Output, Option 021, or Remote Control, Option 022. Additionally, if Option 020, Systems Expand, is ordered with the initial purchase, then either digital output and/or remote control can be ordered separately as accessories for easy installation at any time. Option 020 includes rear terminal in parallel.

ASCII (Character Serial Bit Parallel) Data Input/Output (Opt 030)

The serial data control and data output option permits the Model 3490A to operate on a single data/control bus with several other instruments. This serial code is an eight bit bite using an ASCII type coding. The unique "Talker/Listener" address structure makes the systems hardware more economical, and the associated software simpler. Also, the serial control/data bus is directly compatible with the Hewlett-Packard Model 9800 series calculators. This option does not require Option 020 Systems Expand.

Specifications

DC voltage

Ranges

Full range display: ±.100000 V, ±1.00000 V, ±10.0000 V, ±100.000 V, ±1000.00 V.

Overrange: *20% on all ranges except 1000 V range.*

Range selection: manual, automatic, or remote (optional).

Performance

Accuracy: ±(% of reading + % of range).

		0.1 V Range	1 V to 1000 V Range
		% rdg. % rng.	% rdg. % rng.
24 hrs	(23°C ± 1°C)	±(0.005 + 0.001)	±(0.004 + 0.001)
30 days	(23°C ± 5°C)	±(0.01 + 0.005)	±(0.008 + 0.002)
90 days	(23°C ± 5°C)	±(0.01 + 0.005)	±(0.01 + 0.002)
6 months	(23°C ± 5°C)	±(0.013 + 0.005)	±(0.013 + 0.002)
1 year	(23°C ± 5°C)	±(0.015 + 0.005)	±(0.015 + 0.002)

Input characteristics

Fully guarded with 140 dB ECMR at dc and 60 Hz ±0.1% with 1 kΩ imbalance between Guard and Low.

Maximum input voltage

0.1 V to 1000 V ranges: ±1500 V peak.

Guard to Chassis: ±500 V peak.

Guard to Low: ±200 V peak.

Input resistance

0.1 V to 10 V ranges: >2 x 10^{10}Ω.

100 V and 1000 V ranges: 10 MΩ ±0.15%.

Maximum reading rate: 5 readings/s.

Normal mode rejection ratio: 50 Hz ±0.1%; 60 Hz ±0.1%: >50 dB.

Notes: 1. On the 1000 V range, add 0.04 ppm/volt to the % of reading specification.
2. Thermal EMF's generated external to the DVM may be compensated to achieve the % of range accuracy specified by utilizing the rear panel zero adjust provided in the 3490A.

AC voltage

Ranges

Full range display: 1.00000 V, 10.0000 V, 100.000 V, 1000.00 V.

Overrange: 20% on all ranges except 1000 V range.

Range selection: manual, automatic, or remote (optional).

Performance

Accuracy: ±(% of reading + % of range):

		20 Hz - 50 Hz	60 Hz - 100 kHz	100 kHz - 260 kHz
24 hrs	(23°C ±1°C)	±(0.24 +0.05)	±(0.09 +0.025)	±(0.7 +0.06)
30 days	(23°C ±5°C)	±(0.25 +0.05)	±(0.1 +0.025)	±(0.75 +0.06)
90 days	(23°C ±5°C)	±(0.25 +0.05)	±(0.1 +0.025)	±(0.75 +0.06)
6 months	(23°C ±5°C)	±(0.3 +0.06)	±(0.1 +0.03)	±(0.75 +0.07)
1 year	(23°C ±5°C)	±(0.35 +0.07)	±(0.12 +0.035	±(0.75 +0.08)

Input impedance

Without rear terminals: 2 MΩ ±1% shunted by <65 pF.

With rear terminals: 2 MΩ ±1% shunted by <90 pF.

Maximum reading rate: 1 reading/s.

Response time: <1 s to within rated accuracy for a step input applied coincident with encode trigger.

Maximum input voltage: 1000 V rms; ±1500 V peak.

Notes: 1. Guard must be connected to Low.
2. On the 1000 V range add 0.01 ppm/(volt-kHz).
3. Frequencies >100 kHz specified on 1 V and 10 V ranges only.
4. Specifications are for input levels above 1/100th of full scale.

Ohms

Ranges

Full range display: .100000 kΩ, 1.00000 kΩ, 10.0000 kΩ, 100.000 kΩ, 1000.00 kΩ, 10000.0 kΩ.

Overrange: 20% on all ranges.

Range selection: manual, automatic, or remote (optional).

Performance

Accuracy: ±(% of reading + % of range).

General

Data output (BCD), Option 021

The data output is 1-2-4-8 TTL output which is compatible with the HP 562A, 5050B, and 5055A Digital Recorders. Either high true or low true logic code can be selected with an internal switch.

Remote control, Option 022

The remote control option uses a low true logic (BCD type) code. The required voltage levels for input signal and the output signal levels are listed below.

BCD and remote terminals

	High Level	Low Level
DVM Inputs	+3.9 V ±1.5 V, 100 μA max	+.3 V ±.3 V, 2 mA max
DVM Outputs	+3.9 V ±1.5 V, 400 μA max	+.3 V ±.3 V, 15 mA max

Operating temperature: 0°C to 50°C.

Warm-up time: one hour warm-up required to meet all specifications on the 0.1 V range and the 0.1 kΩ range. Thirty minutes warm-up required to meet all other specifications.

Humidity range: <95% R.H., 0°C to 40°C.

Storage temperature: −40°C to +75°C.

Power: 100/120/220/240 V +5%, −10%, 48 Hz to 400 Hz line operation ≤60 VA with all options.

		0.1 kΩ		1 kΩ - 100 kΩ		1000 kΩ		10,000 kΩ	
		% rdg	% rng	% rdg	% rng	% rdg	% rng	% rdg	% rng
24 hrs	(23°C ±1°C)	±(0.006	+0.001)	±(0.005	+0.001)	±(0.007	+0.001)	±(0.025	+0.001)
30 days	(23°C ±5°C)	±(0.012	+0.005)	±(0.010	+0.002)	±(0.012	+0.002)	±(0.035	+0.002)
90 days	(23°C ±5°C)	±(0.012	+0.005)	±(0.012	+0.002)	±(0.015	+0.002)	±(0.035	+0.002)
6 months	(23°C ±5°C)	±(0.015	+0.005)	±(0.015	+0.002)	±(0.020	+0.002)	±(0.040	+0.002)
1 year	(23°C ±5°C)	±(0.018	+0.005)	±(0.018	+0.002)	±(0.025	+0.002)	±(0.050	+0.002)

Note: Thermal EMF's generated external to the DVM may be compensated to achieve the % of range accuracy specified by utilizing the rear panel zero adjust provided in the 3490A.

Terminal characteristics

Maximum voltage generated across unknown: 20 V for overload; 13 V for valid reading.

Current thru unknown

0.1 kΩ to 10 kΩ range: 1 mA.

100 kΩ to 1000 kΩ range: 10 μA.

10,000 kΩ range: 1 μA.

Overload protection

Non-destructive: 250 V rms.

Fuse destructive: ±1000 V peak.

Maximum reading rate

0.1 kΩ to 100 kΩ range: 5 readings/s.

1000 kΩ range: 4 readings/s.

10,000 kΩ range: 2 reading/s.

Options available

Option 020: systems expand, includes rear terminals in parallel, add $200.

Option 021: BCD*—full parallel, 1-2-4-8 code, [illegible]

Option 022: remote*—full parallel, 1-2-4-8 code, [illegible]

Option 040: sample-and-hold*, add $450.

Option 080: three-wire ratio, add $200.

Option 030: ASCII remote control and data output, add $900.

Option 050 or 060: 50 Hz or 60 Hz operation, no charge.

Rack mounting kit furnished.

*These Options require System Expand Option 020. (Sample-and-Hold requires 020 or 030).

Note: Rack mounting requires support in the rear of the instrument.

Dimensions: 16¾" wide, 3-15/32" high, 18¾" deep (425 x 88 x 425 mm).

Weight: net, 20 lbs 11 oz (9,45 kg); shipping, 26 lbs (11,70 kg).

Price

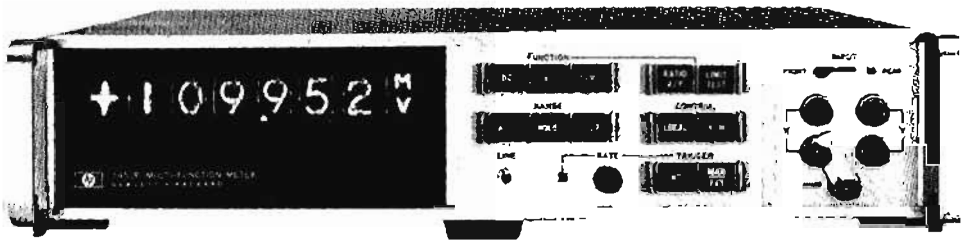
Standard 3490A, (includes ac, dc and ohm), $[illegible]650

Specify Option: 050 (Noise Rejection for 50 Hz), or Option 060 (Noise Rejection for 60 Hz) when ordering. (No additional charge.)

MULTI-FUNCTION METER

Twelve measurement functions including ratio

Model 3450B



3450B

NEW

Description

The Hewlett-Packard Model 3450B Multi-Function Meter is a five-digit integrating digital voltmeter. The basic instrument measures dc voltage and dc voltage ratios. Added measurement capability is achieved by the addition of plug-in options, all of which can be easily installed in the field.

The 3450B uses a dual-slope integration technique and is fully guarded, providing excellent noise immunity at 15 readings per second on all dc ranges. Ranging is automatic over all ranges on all functions. Adding the ac option allows you to make ac measurements from 45 Hz to 1 MHz with true rms response. Six ohms ranges including a 100Ω range are provided with the ohms option.

Ratio capability is integral in the basic instrument. When the ac and ohms options are installed, ac and ohms ratios can be measured. Ratio measurements are made in a truly isolated fashion, allowing measurements never before possible.

A limit test option allows digital comparisons against two preselected limits. This capability is applicable to all functions with no degradation in function performance. Digital output, remote control and rear input options are also available, allowing you to tailor order a 3450B to meet your precise measurement needs.

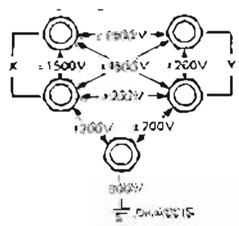
Range	Specification
1 V thru 1000 V	±(0.008% of reading +0.002% of range)
100 mV	±(0.008% of reading +0.01% of range)

90 Day (25°C ±5°)

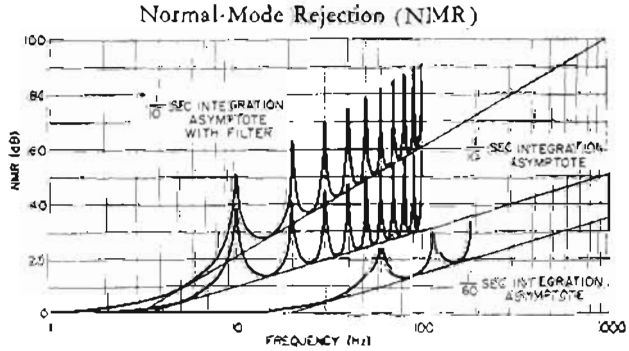
Add 0.002% of range to 30 day specifications.

Integration Period	Reading Period (without range change)	Autorange Time (per range change)
1/10 s	380 ms	380 ms
1/60 s	65 ms	65 ms

Range	Specification
100 mV, 1 V and 10 V	$>10^{10}\Omega$ (10 MΩ ±0.1% selectable by external closure to ground)
100 V and 1000 V	10 MΩ ±0.1%



Normal-Mode Rejection (NMR)



*Filter available in H01-3450B (60 Hz) or H13-3450B (50 Hz).

Effective Common-Mode Rejection (ECMR)

DC: 160 dB.

1/10 s integration period: min of 145 dB.**

1/60 s integration period: min of 130 dB.**

**Rejection cusps added as shown in normal-mode rejection specifications.

AC voltage—Option 001

True RMS-Responding (45 Hz to 1 MHz).

Ranges

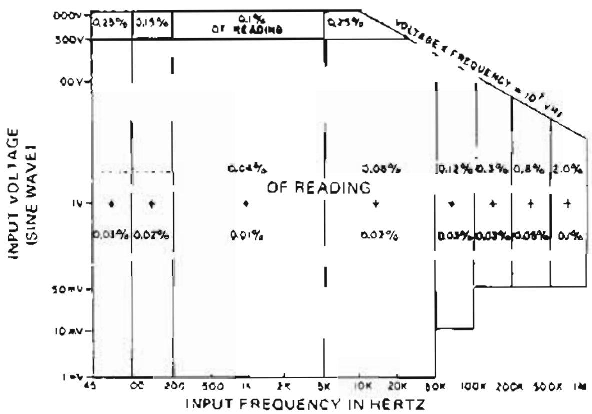
Full range display: 1.00000 V, 10.0000 V, 100.000 V, and 1000.00 V.

Overranging: 20% on all ranges. (1500 V peak on 1 kV.)

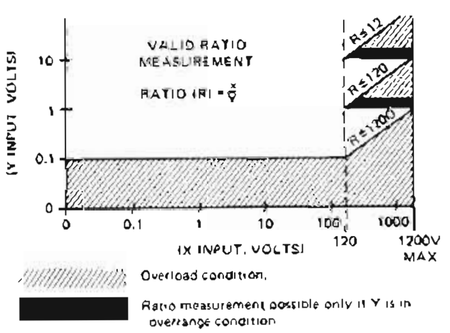
Range selection: manual or automatic. Remote optional.

Performance

Accuracy: 90 day (25°C ±5°C).



Integration Period	Reading Period (without range change)	Autorange Time (per range change)
1/10 s	2.7 s	2.7 s



Overranging: 20% on all ranges.

Range selection: manual or automatic for X input. Remote optional for X input. Automatic for Y input.

Performance

Accuracy

90 day (25°C ±5°C).

$\pm$(0.01% of reading* +0.002% of ratio range

$$+ \frac{\text{Y range}}{\text{Y voltage}} \times 0.003\%)$$

*Add 0.005% of reading for X input >100 V.

Input characteristics

Input configuration: isolated four-terminal, guarded. No common ground necessary between signals.

Input resistance: same as DC VOLTAGE for both X and Y inputs.

Effective common-mode rejection (ECMR): same as DC VOLTAGE for X input.

Normal-mode rejection: same as DC VOLTAGE for X input.

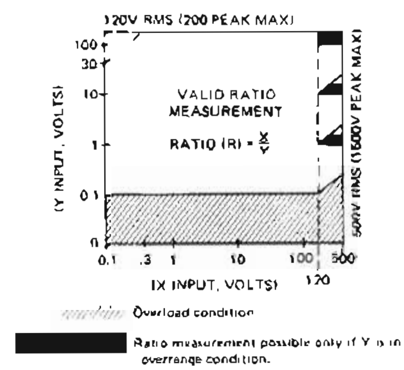
Maximum input voltage: same as DC VOLTAGE.

AC ratio—Option 001

True rms-responding

Ranges

Ratio capability



Overranging: 20% on all ranges.

Range selection: manual or automatic for X input. Remote optional for X input. Automatic for Y input.

Performance

Accuracy: 90 day (25°C ±5°C).

±(0.02% of reading +0.01% of ratio range + sum of accuracies of X and Y inputs determined from ac accuracy graph).

Input characteristics

Input configuration: isolated four-terminal, guarded.

Input impedance: same as AC VOLTAGE for X and Y.

Crest factor: 7:1 (f>1 kHz, bandwidth = 1 MHz).

Maximum input voltage: same as DC VOLTAGE, except <±1000 V dc offset voltage on X terminals.

Ohms—Option 002

Ranges

Full range display: 100.000Ω, 1.00000 kΩ, 10.0000 kΩ, 100.000 kΩ, 1000.00 kΩ, and 10000.0 kΩ.

Overranging: 20% on all ranges.

Range selections: manual or automatic. Remote optional.

Performance

Accuracy: 30 day (25°C ±5°C).

Range	Specification
100 Ω	±(0.01% of reading +0.01% of range)
1 kΩ 10 kΩ 100 kΩ	±(0.01% of reading +0.002% of range)
1000 kΩ	±(0.02% of reading +0.002% of range)
10000 kΩ	±(0.1% of reading +0.002% of range)

90 day (25°C ±5°C): add 0.002% of range to 30 day specifications.

Measuring speed

Integration Period	Reading Period (without range change)	Autorange Time (per range change)
1/10 s	380 ms	380 ms
1/60 s	65 ms (165 ms on 10 MΩ range)	65 ms (165 ms on 10 MΩ range)

Input characteristics

Input configuration: four-wire, guarded.

Current through resistance

Range	Signal Current
100Ω 1 kΩ 10 kΩ	1 mA
100 kΩ 1000 kΩ	10 μA
10000 kΩ	1 μA

Effective common-mode rejection (ECMR): same as DC VOLTAGE.

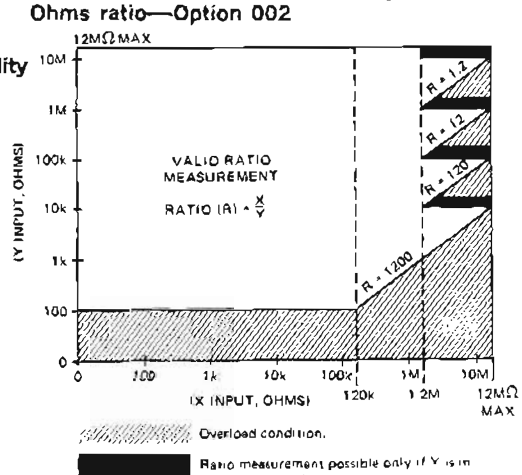
Normal-mode rejection: same as DC VOLTAGE.

Overload protection: ±200 V peak for X or Y input.

Ohms ratio—Option 002

Ranges

Ratio capability



Overranging: 20% on all ranges.

Range selection: manual or automatic for X input. Remote optional for X input. Automatic for Y input.

Performance

Accuracy: 30 day (25°C ±5°C at terminals).

±(% of ratio range + % of ratio reading error)

Where:

$$\% \text{ of ratio range error} = +\left(0.004\% + \frac{\text{Y Range}}{\text{Y Resistance}} \times 0.002\%\right).$$

% of ratio reading error is the greater percentage given below for either X or Y resistance.

0–100	100–1 k	1 k–2 k	2 k–9 k	9 k–500 k	500 k–5 M	5 M–12 M	Ω
5	0.55	0.1	0.05	0.02*	0.05	0.2	%

*0.01% for ratios between 0.95 and 1.05 if X and Y are between 10 k and 500 k.

Y ranges: 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ and 10 MΩ.

90 day (25°C ±5° at terminals)

Same as 30 day specification except % or Ratio range

$$\text{error} = +\left(0.004\% + \frac{\text{Y Range}}{\text{Y Resistance}} \times 0.003\%\right)$$

Input characteristics

Input configuration: isolated four-terminal, guarded. Two wires per resistor.

Current through X and Y resistance: same as OHMS function.

Effective common-mode rejection (ECMR): same as DC VOLTAGE for X input.

Normal-mode rejection: same as DC VOLTAGE for X input.

Overload protection: ±200 V peak for X or Y input.

Price: Option 002 Ohms Converter (adds ohms and Ohms ratio), add $425.

Limit test—Option 003

Capability

Applicable to: DC, DC RATIO, AC, AC RATIO, OHMS and OHMS RATIO.

No degradation in performance of above six functions.

Limit selection

Two 4-digit limits (with 20% overranging), including polarity, are selectable in 1-2-4-8 BCD form with external closure to ground through <3 kΩ (2.8 mA max) or application of −0.5 V to +2.5 V.

Output signals

Limit indications: HI, GO, LO front panel lights defined as follows: High limit ≤ HI
Lower Limit ≤ GO <High Limit
LO <Lower Limit

Price: Option 003 Limit Test, add $375.

Digital output—Option 004

Print command: dc coupled.

Print level: 0 V, 12 mA max current.

No print level: 12 V or 5 V, determined by logic level selected.

Trigger or print command hold off: *−0.5 V to +2.5 V, 9 mA max current.

*Holdoff on internal trigger or print command may be selected by moving jumper wire.

BCD outputs: four-line BCD (1-2-4-8) "1" state positive, nine columns of information, as follows:

2 columns for function and polarity.
1 column for range or ratio range.
6 columns for digital data.

Price: Option 004 Digital Output, add $225.

Remote control—Option 005

All remote control lines are selected by an external closure to ground through <3 kΩ (2.8 mA max) or application of −0.5 V to +2.5 V.

Remote controls

**1/60 s integration period.	Program remote.
**100 ms delay.	Program external trigger.
**10 MΩ input resistance.	Front-panel lockout.
**External trigger.	Non-ratio remote range.
Remote function.	Remote ratio range.
	Remote decimal.

**These remote capabilities are included in the basic 3450B and do not require the addition of Option 005.

Price: Option 005 Remote Control, add $260.

General

Operating temperature: 0°C to 50°C, unless otherwise specified.

Storage temperature: −40°C to +75°C.

Power: 115 V or 230 V ±10%, 50 Hz to 400 Hz, <75 W (including all options, normal environmental conditions).

Dimensions: 16¾" wide, 3-15/32" high, 21⅜" deep (425 x 88 x 542 mm).

Weight

Basic instrument: net, 31 lbs (14,1 kg).

Including all options: net, 36 lbs (16,3 kg).

Shipping: 50 lbs (22,7 kg).

Price: HP 3450B (includes DC and DC Ratio), $3500.

HP H50-3450B, Optimum Noise rejection for 50 Hz line, $3560.

HP H01-3450B, Optimum Noise rejection for 60 Hz line with programmable filter, $3800.

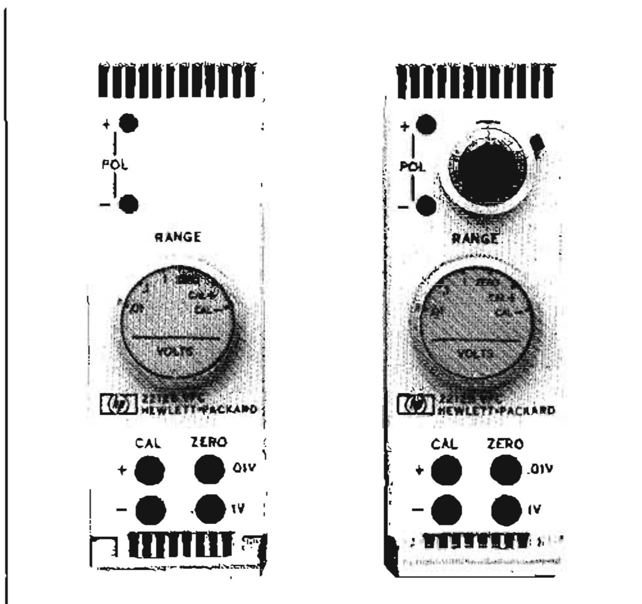
HP H13-3450B, Optimum Noise rejection for 50 Hz line with programmable filter, $3860.

Option 006, Rear Input Terminals, add $70.
(Add Front/Rear selector switch and rear terminals.)

V-TO-F CONVERTER

Accurate bipolar, low-level dc V-to-F conversion

Model 2212B



2212B   Option 002

The HP 2212B is a compact Voltage-to-Frequency Converter, well suited to low-level signal applications. Low input drift and high common mode rejection (114 dB at 60 Hz) are achieved without a chopper by differential circuits. The VFC produces an output pulse train with a rate directly proportional to the magnitude of an applied dc voltage. Pulse rate rises linearly and instantaneously from 0 to 100,000 pulses per second as the dc input level is increased from zero to full scale. The 2212B provides outstanding linearity, stability and noise immunity

The output of the HP 2212B, when connected to an electronic counter provides a convenient method of making digital measurements of dc voltages; the converter provides a polarity signal. This converter-counter combination can be connected directly to a digital printer or through an output coupler to other common digital recording devices.

The converter-counter combination integrates dc voltages over any period of time and can therefore be used to read the average of the input over a selected sample period, or over an externally-controlled period. This provides accurate dc measurements in the presence of noise superimposed on the signal. Combining the VFC with an HP 5321B all-IC Counter, provides an Integrating DVM with .01, .1, 1 and 10 seconds sample periods.

The modular package with self-contained power supply allows the 2212B to be used in both bench and systems applications. An inexpensive combining case is available to mount 10 instruments side-by-side in only 5¼″ of 19″ rack panel space.

Specifications

	.01 V		.1 V		1 V	
Stability	.07	.06	.05	.015	.02	.011
Linearity		.01		.01		.01
Temp. Coeff.	.004	.017	.004	.0035	.004	.0022

Internal calibration source: 1 V standard for self-calibration. Accurate to within ±0.02% for six months; temp. coeff of ±0.005% per °C (0° to 55°C).

Differential input impedance: 1000 MΩ shunted by 0.001 μF.

Common mode rejection: 120 dB at dc; 114 dB at 60 Hz.

Common mode return: From input common to output common, 1 megohm, max.

Normal mode rejection: More than 40 dB at 55 Hz with 1 second sample period; increases 20 dB per decade increase in noise frequency. Infinite rejection cusp every cycle.

Slewing: 1 V/μs rti (referred to input) with dc offset caused by slew limiting less than 0.1% of peak ac, provided 250% of full scale is not exceeded.

Maximum input signal: ±11 V, signal plus common mode. Combined input up to ±20 V will not damage instrument.

Output (dc coupled): 0 to 100 kHz fs, overranging to 250 kHz; 5 mA available; short circuit will not damage instrument.

Settling time: 100 μs to within 0.01% of final pulse rate.

Overload recovery: 200 μs to 0.01% of final pulse rate for signal to 10 times full scale. Less than 5 ms for signal plus common mode input up to 20 V.

Polarity indication: electrical and visual for + and −.

Operating conditions: Ambient temperatures from 0° to 55°C; relative humidity to 95% at 40°C.

Warmup: operates immediately after turn-on, but requires 1½ hours in free air, 30 minutes in portable case or combining Case (plus 1 hour additional warmup for each 10°C difference between storage temperature and operating ambient) for specified accuracy and zero drift.

Reliability: predicted MTBF (with 90% confidence) is 10,000 hours when operated at 25°C ambient.

Power: 115 or 230 V ±10%, 50 to 400 Hz, 10 VA max.

Dimensions: 1$\frac{9}{16}$″ wide, 4⅞″ high, 15″ deep (39.7 x 123.8 x 381 mm).

Weight: net 4 lb (1,8 kg), shipping 6½ lb (2,9 kg).

Accessories available: mating rear connector; mating rear connector with power cord, input/output cable; combining case: holds up to 10 instruments in 5¼″ of 19″ rack space (mating connectors furnished), includes power cord and fan; portable case: holds two VFC's (mating connectors furnished) and includes power switch, pilot light, power cord and fan.

Price: HP 2212B, $1325; option 002 (Vernier) add $100.

INTEGRATING DVM

Precise measurements despite severe noise

Model 2402A

The 2402A Integrating Digital Voltmeter combines 43 measurement per second sampling rate and the precision and measurement flexibility expected from a laboratory instrument with the programming and electrical output features necessary for data acquisition systems use both computerized and non-computerized. It achieves high speed and high accuracy at low levels, without preamplifiers.

Instrument design virtually eliminates errors caused by extraneous noise without imposing any restrictions on the grounding of the signal source, recording device, or programmer, or upon the measuring speed of the instrument. The controls and input/output features of the 2402A permit maximum versatility of application, yet the instrument is straightforward to use.

High accuracy in a DVM is of little practical value unless this accuracy can be maintained in the presence of noise and under the far from ideal conditions of everyday use. The 2402A is average-reading, which greatly reduces the effects of superimposed noise. A floated and guarded input circuit eliminates common mode noise error. Combined, these techniques yield effective common mode noise rejection greater than 126 dB (2 million to 1) at any frequency, including dc.

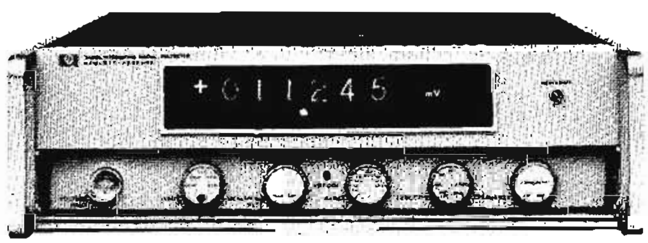
The 2402A reads the average value of the applied voltage over a 1/60 second sample period, and provides maximum rejection of superimposed noise at 60 Hz (1/50 second optional). Since no input filters are employed, it provides both noise rejection capability and rapid accurate response to step input required for data acquisition system applications. Superimposed noise rejection holds for combined signal plus noise amplitudes to 130% of full scale.

The 2402A features a guard that completely isolates the floating measuring circuit from the chassis, breaking the common mode loop. To take a practical example of the 2402A noise rejection, the combined effect of guarding and averaging at 60 Hz is such that a 100 V peak-to-peak common mode potential will not cause a discernible error in reading on any range.

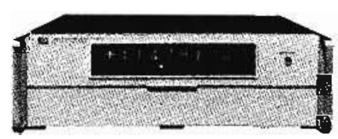
AC voltages to 750V peak can be measured on four ranges from 1V to 1000V when the 2402A is equipped for optional ac voltage measurement. It is adapted for ac voltage measurement by installation of plug-in ac-to-dc converter and control boards. The converter is average-reading and is calibrated in rms with respect to sinusoidal input. The dc voltage input connectors are also used for ac input. The same guard provides common mode rejection for ac and dc voltage measurements. The overload detection circuit of the basic 2402A protects the ac converter.

Resistance measurements to 13 megohms can be made on five ranges from 1k Ω to 10M Ω when the 2402A is equipped with this option. It is adapted for resistance measurement by installation of plug-in ohms-to-dc converter and control boards and a 4-wire guarded rear panel connector. The converter is installed inside the guard, assuring freedom from common mode errors.

The 2402A may be equipped for frequency measurements to 199.999 kHz. Frequency measurement is a plug-in option.



2402A Integrating Digital Voltmeter



Cover flips up to protect controls in systems use.

Specifications

(For ±10% line voltage variation and 6 months operation, assuming daily calibration against internal standard after 30-minute warm-up.)

DC voltage measurement

Noise rejection: overall effective common mode rejection: (ratio of common mode signal to its effect upon readings): 160 dB at dc, decreasing to 126 dB above 30 Hz (infinite rejection cusp gives 168 dB effective cmr at 60 Hz ±.15%). Overall rejection combines common mode rejection and superimposed noise rejection.

Input circuit: type: floated and guarded signal pair. Signal low and guard may be floated up to 500 V above chassis ground with up to 1000 V input signal (maximum low-to-guard voltage is 50 V).

Ranges: 100 mV and 1, 10, 100, and 1000 V full scale selected by front panel switch, external programming or autoranger.

Overranging: to 130% of full scale, except on 1000 V range. Self protected on any range against input voltage to 1000 V. Protective circuits reset automatically for each new reading.

Input impedance: greater than 1000 MΩ on 100 mV, 1 V and 10 V ranges; 10 MΩ on 100 and 1000 V ranges.

Internal calibration standard: (independent of measuring circuit). Derived from stabilized reference diode operating in a constant temperature oven; maintain specified accuracy for 6 months.

Measurement speed: to 43 measurements per second when triggered externally. Self-triggers at speeds continuously adjustable from 1 measurement every 10 seconds to 10 per second.

Accuracy: (source impedance 10 kΩ, 43 measurements per sec, ±10% line voltage variation after 60-minute warmup.)

Range	1 V, 10 V, 100 V, 1000 V	100 mV
Short term (24 hour) Accuracy (at 25 ± 1°C)	.003% rdg ± .003% fs (.006% rdg in overrange)	.003% rdg ± .005% fs (.008% rdg in overrange) Below 30 mV accuracy improves to 3μV±.008% rdg.
Long term (6 months) Accuracy (at 25 ± 1°C)	.01% rdg ± .003% fs (.013% rdg in overrange)	.01% rdg ± .005% fs (.015% rdg in overrange) Below 30 mV accuracy improves to 3μV ± .015% rdg.

TEMP EFFECT	Per °C change from Calibrate temperature	
15 to 40°C	.0015% rdg ±.00015% fs	.0015% rdg ±.0006% fs
10 to 15°C or 40 to 50°C	.002% rdg ±.00015% fs	.002% rdg ±.0006% fs

Resolution: 1 part in 130,000 on 6-digit display: 100 mV range displays readings to 1 μV.

AC voltage measurement (option 002)

Common mode rejection: 160 dB at dc, decreasing to 120 dB at 60 Hz and 6 dB per octave for noise frequencies above 60 Hz, with 10Ω between guard connected to low side of source and low side of input.

Input circuit: floated and guarded signal pair. Signal low and guard may be floated up to 500 V above chassis ground with maximum input voltage applied.

Input voltage limitations: 240 V peak on 1 V range, 750 V peak on all other ranges without damage.

Input impedance: 1 MΩ ±1% shunted by 200 pF (maximum).

AC only operation: frequency range: 50 Hz to 100 kHz.

Ranges: 1, 10, 100, and 1000 V full scale, selected by front panel switch, external programming or autoranger.

Overranging: to 130% of full scale, except 530 V rms. on 1000 V range.

Accuracy (with respect to standard used for calibration):

SIGNAL FREQUENCY (1)	50 Hz		100 Hz		10 kHz		30 kHz		100 kHz	
	% rdg ± % fs		% rdg ± % fs		% rdg ± % fs		% rdg ± % fs		% rdg ± % fs	
Accuracy (at 25 ± 1°C)	.09	.05	.06	.03	.06	.03	.09	.05	.3	.09
Response error (2)	.1	–	.05	–	.02	–	.02	–	.02	–
Ripple error (3)	.03	–	.02	–	–	–	–	–	–	–
Temperature effect (4) (Per °C change in ambient from 25°C, over 10 to 50°C range)	.004	003	.004	.003	.004	.003	.007	.003	.013	003

(1) Straight line interpolation holds for frequencies between points.
(2) Applicable only to step input (received from data system signal scanner) or autorange operation.
(3) Ripple error decreases 18 dB per octave above 85 Hz, is zero at 60 Hz because of superimposed noise rejection of basic instrument.
(4) Assumes calibration of 2402A against internal standard at 25°C ambient. Calibration of 2402A at operating temperature decreases % rdg temperature effect .0009% per °C.

AC on DC operation: maximum dc component: ±200 V on any range.

Ranging: must start from 1000 V range, proceed to lower range as required.

Peak input: ac plus dc to 100% of full scale, except 750 V peak maximum on 1000 V range.

Measurement speed: to 1.9 externally-triggered measurements per second. Self-triggered measurement rate adjustable from 1 measurement every 10 seconds to 1.6 per second.

Resolution: 1 part in 130,000 on 6-digit display; 10 μV on 1 V range.

Resistance measurement, (option 003)

Noise rejection: measurement circuit enclosed in same guard as dc circuit, reducing effect of ac common mode noise when guard is connected to low side of test resistance. Double-shielded cable extends guard to test resistance.

Input circuit: guarded, modified four-terminal circuit; unknown resistor can be either grounded or floating.

Ranges: 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, and 10 MΩ full scale, selected by front panel switch, external programming or optional autoranger.

Overranging: to 130% of full scale. Self-protected on all ranges against up to 50 V across resistance input.

Absolute accuracy:

Resistance range	1 kΩ	10 kΩ	100 kΩ	1 MΩ	10 MΩ
Measurement current	1 mA	1 mA	100 μA	10 μA	1 μA
Accuracy at 25°C	% rdg ± % fs .016 .003	.013% rdg ± .003% fs			% rdg ± % fs .025 .005
Temperature (1) effect	.004% rdg ± .0003% fs per °C difference of ambient with respect to 25°C over 10 to 50°C range				

(1) Calibration of 2402A against internal standard at operating temperature decreases % rdg temperature effect .0015% per °C. to 0025% rdg per °C.

Measurement speed: to 8 externally triggered readings per second. Self-triggered measurement rate is adjustable from 1 measurement every 10 seconds to 4.5 per second.

Resolution: 1 part in 130,000; .01Ω on 1 kΩ range.

Frequency measurement (option 005)

Frequency range: 5 Hz to 199.999 kHz.

Gate time: 1 second; provides 1 Hz resolution.

Accuracy: (±1 count ± time base stability); time base aging rate: 2 ppm per week over 20 to 30°C; time base temperature effect: 100 ppm over range 10 to 50°C.

Input

Amplitude range: .1 to 100 V rms.

Pulse or square wave input: negative 1 to 100 V amplitude, 2 μs minimum duration, 50% maximum duty cycle.

Impedance: 1 MΩ shunted by 150 pF.

Maximum voltage: 150 V peak dc plus ac or pulse.

Autorange (option 001)

Range selection: DC voltage ranges; each time autoranger is programmed, it starts on 1 V range to take advantage of fast up-ranging. While autoranging is continuously programmed, autoranger starts at range selected for previous reading, sequences to higher or lower range as required. AC voltage ranges; autoranger starts at 1000 V range, sequences to lower range as required. Up-ranges at 136% of full scale, down-ranges at 10.2%.

General

Display and system interface: 6-digit display, BCD output and program inputs. Polarity, decimal, measurement units, calibration, and overload conditions indicated automatically and included in output as function and decimal digits.

Operating conditions: specifications apply for ambient temperatures 10 to 50°C, relative humidity to 90% at 40°C, altitude to 15,000 feet, maximum storage temperature 40°C.

Power: 115 or 230 V ±10%, 50 to 60 Hz, 150 W.

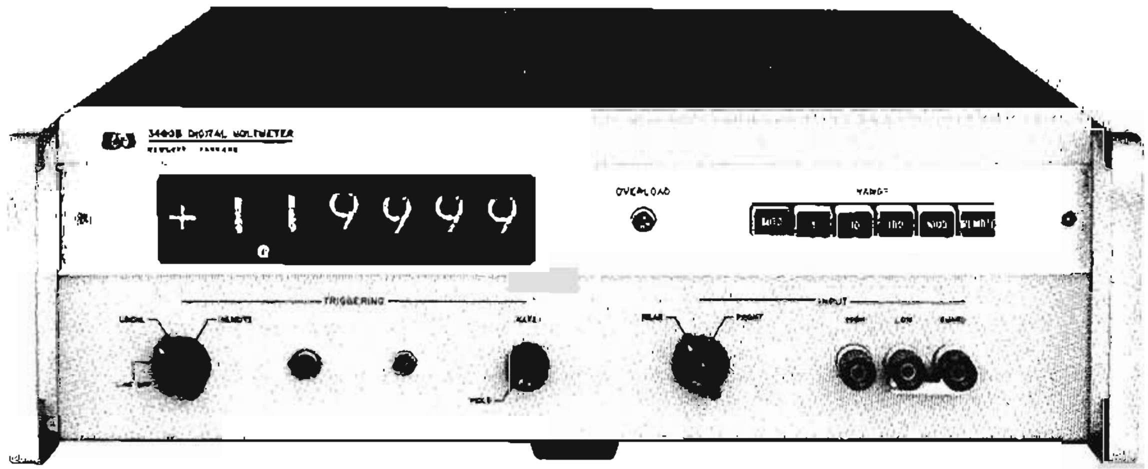
Dimensions: 16¾" wide, 5¼" high, 19½" deep behind panel (425 x 133 x 495 mm); hardware furnished for 19" wide rack mount.

Weight: net 49 lbs (22,2 kg); shipping 56 lbs (25,4 kg).

Price: 2402A for DC measurements, $6500; AC adds $675; resistance adds $775; frequency adds $350; autoranging adds $265.

DIGITAL VOLTMETER

±0.004% accuracy, lab precision, systems speed
Model 3460B



3460B

Description

The all solid-state Hewlett-Packard 3460B Digital Voltmeter is a full five-digit digital voltmeter which combines in one instrument the benefits of high accuracy, high resolution, high speed, high noise rejection and constant high-input impedance. The unique method by which the potentiometric and integrating techniques are combined in this instrument is primarily responsible for this combination of outstanding features, which has sustained the 3460B's position as one of the most highly accurate DVM's available.

This guarded digital voltmeter permits automatic and remote-controlled dc measurements from 1 V to 1000 V full scale. Measurements of 1 volt can be obtained with 10 μV resolution. A high accuracy of ±0.004% of reading ±0.002% of full scale makes the 3460B ideal for precision measurements. The unique two-sample system of the HP 3460B enables 15 independent readings to be made in one second at this accuracy. Integration during the second of these two samples plus guarding, results in excellent effective common-mode rejection and ac normal-mode rejection characteristics. 20% overranging on all ranges offers full-scale display within specified accuracy (up to 1200 V on the 1000 V range). Another feature is the choice of constant 10 MΩ input impedance or $10^{10}\Omega$ input impedance on the 1 V or 10 V range. In-line digital display tubes and the polarity indicator display voltage measurements from ±0.00001 to ±1199.99 V dc. These measurements are made with an absolute accuracy of ±0.004% of reading ±0.002% of full scale over a temperature range from +20°C to +30°C for a period of 90 days. Voltage accuracy temperature coefficient is ±0.0002% of reading/°C over a temperature range of 0°C to +50°C. Four input voltage ranges of 1.00000, 10.0000, 100.000, 1000.00 may be selected by front-panel pushbuttons, automatically or by remote control. A decimal point is automatically positioned so that the display always reads directly in volts.

Integrating-potentiometric technique

The 3460B is distinctly different from all other types of digital voltmeters. It combines potentiometric and integration techniques and continually measures the true average of the input voltage over a fixed sampling period. It attains ±0.004% accuracy as a result of the potentiometric technique which makes use of resistance ratios and a stable reference voltage. The use of integration in this combined technique results in much of the superimposed noise immunity of integrating DVM's. The voltmeter, in one 5" high, 19" wide convenient rack-mount unit, combines the extreme precision and measurement flexibility expected from laboratory standards with the programming and electronic output features necessary for automatic systems.

Programming the 3460B

The HP 3460B is designed for fully automatic operation within a digital data acquisition system. Measurement function, voltage range and integration period can all be selected by external circuit closures to ground.

To simplify system cabling, signal input connections can also be made at the rear of the instrument. All remote-control lines and electrical outputs are referred to the chassis. Grounding the chassis does not affect the floating capabilities of the input lines and guard.

Accessory equipment

Permanent test records of all readings including function, polarity, decimal location, and overload condition are available by using an HP Model 562A Digital Recorder which can record up to 5 lines per second, or an HP Model 5050A Digital Recorder which records up to 20 lines per second.

Specifications

Ranges: full scale, ±1.00000 V, ±10.0000 V, ±100.000 V and ±1000.00 V (up to 20% overranging indicated with 6th digit); range selection may be made automatically, remotely, or manually.

Performance rating

Absolute voltage accuracy: ±(0.004% of reading +0.002% of full scale) over a temperature range from +20°C to +30°C for a period of 90 days.

Voltage accuracy temperature coefficient: ±(0.0002% of reading +0.0001% of full scale) /°C over a temperature range of 0°C to +50°C.

Short-term stability: ±(0.002% of reading +0.001% of full scale) at +23°C ±1°C and relative humidity up to 50% for a period of 24 hours.

Long-term stability: ±(0.008% of reading +0.001% of full scale at +23°C ±1°C and relative humidity up to 50% for a period of 6 months.

Response times: fixed range, reads within specified accuracy when triggered coincident with step input voltage. Reading period: 66 ms min on 10, 100, and 1000 V ranges, 147 ms min on 1 V range.

Polarity selection: no delay.

Automatic range selection: 33 ms per range change (100 ms max).

Remote range selection: 8 ms.

Input characteristics

Input Resistance

Range	Specification
1 V and 10 V	$>10^{10}\Omega$ within ±5% of null, otherwise 10 MΩ ±0.03%
100 V and 1000 V	10 MΩ ±0.03%

Impedance: 40 pF in parallel with 10 MΩ at front panel.

Noise rejection: overall effective common-mode rejection (ratio of indicated error voltage to common-mode voltage) 146 dB at all frequencies (0.1 s sample period); common-mode rejection 160 dB at dc, 120 dB at 60 Hz with 1000 Ω between low side of input and the point where the guard is connected; superimposed noise rejection; >20 dB at 55 Hz for 0.1 s sample period increased 20 dB per decade of frequency; infinite rejection at frequencies divisible by 10 (0.1 s sample period) or 60 (1/60 s sample period).

Isolation parameters

Inputs: floated and guarded signal pair (binding post on front panel or connector on rear panel is selected by front-panel switch); guard may be operated up to ±500 V dc with respect to chassis ground (350 V rms); low may be operated up to ±50 V dc with respect to guard.

Input signals

Range selection

Automatic: pushbutton selector or a switch closure to ground with impedance <100 Ω provides auto range operation; 33 ms is required per range change (100 ms max).

Remote: a switch closure to ground with impedance <100 Ω for a period >100 μs selects range desired within 8 ms.

Manual: pushbutton selector.

External Read Command:

Trigger	Open Ckt Voltage	Trigger Level	Duration	Load
Positive going Direct coupled	−10 V	0 V or contact closure to ground	100 μs to 10 ms	1 mA at 0 V 6 mA at +30 V
Negative going Direct coupled	+10 V	−10	100 μs to 10 ms	2 mA at −10 V, 5 mA at −30 V
AC Coupled		20 V p-p with rise time ≤10 μs	>100 μs	6 k ohms in parallel with 25 pF (0.01 μF coupling capacitor used)

Short integration period: voltmeter normally integrates for 1/10 s; switch closure to ground of <100 Ω selects 1/60 s integration period on 10, 100, and 1000 V ranges (3460B providing 1/50 s integration period for 50 Hz line frequency is available on special order).

Voltmeter reset: switch closure to ground of <100 Ω assures min reset time.

Trigger hold off: hold off level is +3 to +10 V with a max current of 6.3 mA (provided by HP 562A Digital Recorder).

Output signals

Print command: dc coupled.

Print level: −1.0 V with 2 kΩ source resistance.

Print hold off level: −17 V with 7.5 kΩ source resistance (min load resistance is 15 kΩ).

BCD outputs: 4-line BCD (1-2-4-8), 9 columns consisting of function (polarity), decimal location, overload, and 6 digits of data (HP 3460B Option 001 available for 1-2-2-4) BCD).

State	Voltage	Source Resistance
0	−24 V	100 kΩ
1	− 1 V	100 kΩ
Ref. Level	**Voltage**	**Source Resistance**
Positive	− 4 V	380Ω
Negative	−21 V	900Ω

Operational features

Trigger selection: front-panel selection of local or remote mode.

Overload indicator: indicates when input voltage is higher than 120% of range selected.

Sampling indicator: indicates when instrument is digitizing.

General

Power: 115 or 230 V ±10%, 50 to 60 Hz, approx 90 VA.

Dimensions: 16¾" wide, 5-7/32" high, 21⅜" deep (425,5 x 132,6 x 543 mm).

Weight: net, 38 lbs (17,2 kg); shipping, 48 lbs (21,8 kg).

Accessories furnished

HP 11065A 6-ft rear input cable, guarding preserved, terminated end mates with 3460B.

HP 11085A remote control cable.

HP rack mounting kit.

Accessories available

HP 562/AR Digital Recorder, basic instrument with 11-column capacity. Column boards, connectors and cables not included. $1485; Rack, $1460.

HP 5050B Digital Recorder, basic instrument with 18-column capacity and 3 code discs. Column boards, and cables required are not included, $1975.

Price: HP Model 3460B, $4295.

Opt. H50, Optimum Noise Rejection for 50 Hz line, add $60.

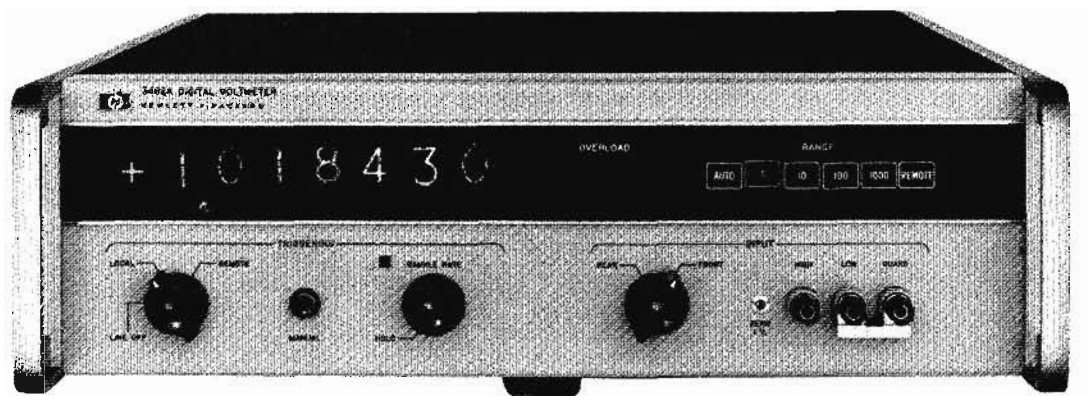
Opt. 001, 1-2-2-4 BCD Output, no charge.

DIGITAL VOLTMETER

Resolution: 1 μV on 1 V; 1 mV on 1000 V range

Model 3462A

3462A



Description

The solid-state Model 3462A, 6-digit DVM, offers a resolution of 1 part in 1,200,000 at 20% overrange. Sensitivity is 1μ V and accuracy is $\pm$(0.004% of reading +0.002% of range) over a 10°C temperature variation for a period of 90 days.

The potentiometric-integrating technique used in the 3460B is also used in the 3462A. The true average of the input voltage is measured over a fixed sample period. Accuracy results largely from the potentiometric principle using precision resistance ratios and a stable reference voltage. This, in combination with the integration and guarding system, results in the superimposed noise immunity of the integrating DVM's while retaining potentiometric accuracy. Virtually no loading errors result from an input impedance of greater than 10^7 ohms.

The 3462A offers a maximum reading rate of 1.1 seconds per reading on all ranges. The 3462A is fully programmable. Digital output for all readings include polarity, decimal location, overload, and seven digits of data.

Null measurements can be performed with 1 μV sensitivity. A front-panel, high-resolution zero adjust is provided to compensate for any thermals in connections to external circuitry. BCD output capability permits recording of data, and remote programmability permits system applications.

Ranging

Voltages are measured on four ranges from $\pm$1 V to $\pm$1000 V full scale. Ranges can be selected automatically, manually, or remotely. An important advantage is the ability to read up to 20% above full scale on any range (1200 V dc on the 1000 V range). An overload condition is indicated on both the front panel and the recorder output when the input is greater than 1.2 times full scale on any range during manual operation or greater than 1200 V in automatic operation.

Automatic selection of the appropriate input voltage range may be made with the front-panel selector or by an external circuit closure to ground. The autoranging circuitry utilizes the full 20% overranging capability of the 3462A.

Programming

The HP 3462A is designed for fully automatic operation within a digital data acquisition system. Voltage range can be selected by external circuit closures to ground.

To simplify system cabling, input connections can also be made at the rear of the instrument. All remote-control lines and electrical outputs are referred to chassis ground and do not interfere with the guard.

Recorder Output

1-2-4-8* binary-coded decimal voltages (ground referenced) are produced for each measurement and for indication of measurement function, voltage range, and polarity. A complete printed record of the 3462A output information can be obtained with an HP Model 562A/AR or HP 5050B Digital Recorder.

Specifications

Ranges

Full range display: $\pm$1.000000 V; $\pm$10.00000 V; $\pm$100.0000; $\pm$1000.000.

Overranging: 20% on all ranges.

Range selection: manual, automatic, or remote.

Performance

Accuracy (90 days, 25°C $\pm$5°C, <50% RH): $\pm$(0.004% of reading +0.0002% of range).

Accuracy (90 days, 25°C $\pm$5°C, <95% RH): $\pm$(0.004% of reading +0.0004% of range).

Stability (constant temperature $\pm$1°C, <50% RH)

24 hr: $\pm$(0.0015% of reading +0.0002% of range).

180 day: $\pm$(0.006% of reading +0.0004% of range).

Temperature coefficient (0°C to 50°C): $\pm$(0.0002% of reading +0.00002% of range) per °C.

Measuring speed

Range	Integration Interval	Reading Period (without range change)	Auto-range Time	Remote Range Time	Polarity Selection Time
1 V 10 V .00 V .000 V	. s	1.1 s	60 ms	8 ms	no delay

Reads within specified accuracy when triggered coincident with step input voltage.

Input Characteristics

Input: floated and guarded signal pair (special gold-plated binding post on front panel or connector on rear panel are selected by front-panel switch). Guard may be operated up to $\pm$500 V dc with respect to chassis ground (350 V rms). Low may be operated up to $\pm$50 V dc with respect to guard.

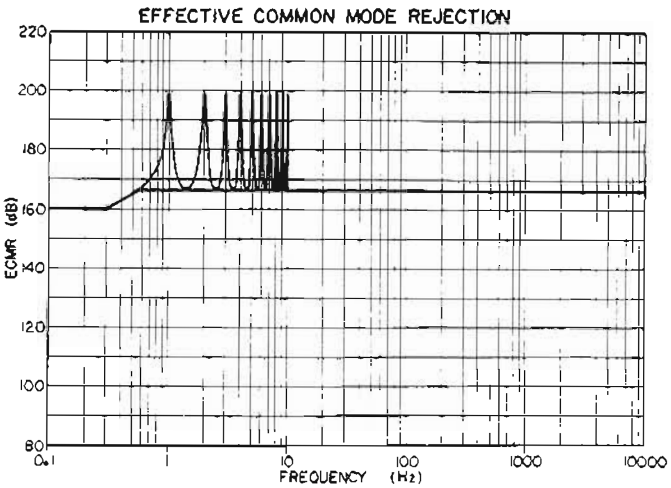
*1-2-2-4 available with HP 3462A Option 001.

Input resistance

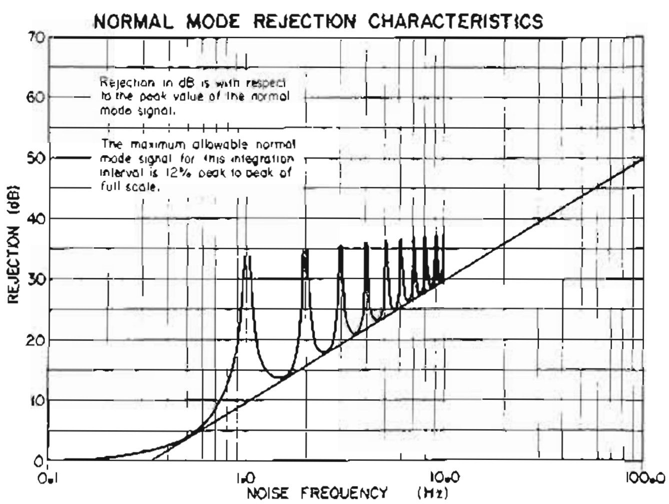
Range	Specifications
1 V and 10 V	$10^{10}\Omega$ within $\pm5\%$ of null, otherwise $10^7\Omega \pm 0.03\%$
100 V and 1000 V	$10^7\Omega \pm 0.03\%$

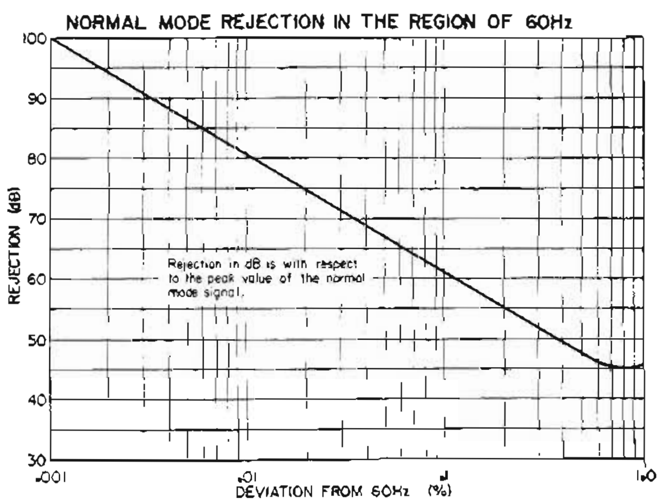
Input Impedance: 40 pF in parallel with $10^7\Omega$ at front panel.

Effective Common-Mode Rejection (ECMR): ECMR is the ratio of the peak common-mode voltage to the resultant error in reading with 1 kΩ unbalance in either lead.



Normal-Mode Rejection (NMR): NMR is the ratio of the peak normal-mode signal to the resultant error in reading.





Remote Control

Range selection

Automatic: pushbutton selector or a switch closure to ground through <100Ω provides autorange operation. 60 ms is required per range change, 180 ms max.

Remote: a switch closure to ground through <100Ω for a period >100 μs selects range desired.

Manual: pushbutton selector.

External Read Command

Trigger	Open Ckt Voltage	Trigger Level	Duration	Load
Positive going Direct coupled	−10 V	0 V or contact closure to ground	100 μs to 10 ms	1 mA at 0 V 6 mA at +30 V
Negative going Direct coupled	+10 V	−10	100 μs to 10 ms	2 mA at −10 V, 5 mA at −30 V
AC Coupled		20 V p-p with rise time ≤10 μs	>100 μs	6 kΩ in parallel with 25 pF (0.01 μF coupling capacitor used)

Voltmeter reset: switch closure to ground through <100Ω assures minimum reading period.

Trigger hold-off: hold-off level is +3 V to +10 V with max. current of 6.3 mA (provided by an external device).

Input resistance: $10^7\Omega$ ±0.03% can be programmed by contact closure to ground of <100Ω.

Recorder Data

Print command: dc coupled.

Print level: −1.0 V with 2 kΩ source resistance.

Print hold-off level: −17 V with 7.5 kΩ source resistance (minimum load resistance is 15 kΩ).

BCD outputs: 4-line BCD (1-2-4-8), 9 columns, consisting of polarity and decimal location, overload, and 7 digits of data (HP 3462A Option 001 is available for 1-2-2-4 BCD).

General

Operating temperature: 0°C to 50°C unless specified otherwise.

Storage temperature: −40°C to +75°C.

RFI: meets MIL-I-6181D.

Power: 115 V or 230 V ±10%, 50 Hz to 60 Hz, 90 VA. Available on special order for operation with powerline frequencies between 50 Hz and 400 Hz.

Dimensions: 16¾" wide, 5" high, 21⅜" deep (425 x 127 x 543 mm).

Weight: net 38 lbs (17,2 kg); shipping 56 lbs (25,4 kg).

Accessories furnished

HP 11065A 6-ft rear input cable, guarding preserved, terminated end mates with 3462A. ($20 for additional cable.)

HP 11085A remote control cable. ($30 for additional cable).

HP rack mount kit.

Accessories available

HP 562A/AR Digital Recorder, basic instrument with 11-column capacity. Column boards, input connector assemblies and cables required for operation are not included. $1485; rack, $1460.

HP 5050B Digital Recorder, basic instrument with 18-column capacity and 3 code discs. Column boards and cables required for operation are not included. $1975.

Price: HP 3462A, $5390.

HP 3462A option 001 (1-2-2-4 BCD output), $5390.

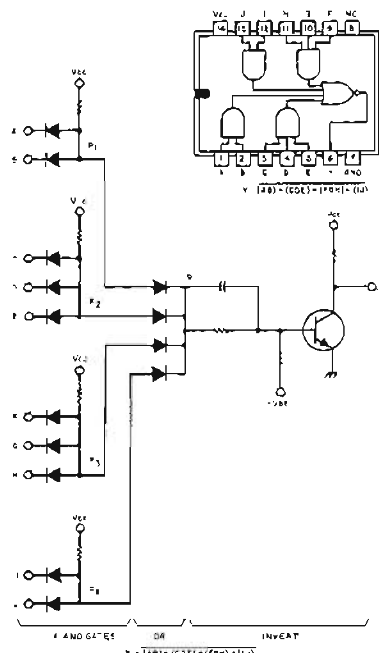
HP 3462A option H50 (optimum noise rejection for 50 Hz line frequency), add $60.

HP 3462A option 001, option H50 (1-2-2-4 BCD output and optimum noise rejection for 50 Hz line frequency), add $60.

Digital IC's—Friend or Foe?

It's no surprise that the digital IC has produced an unprecedented revolution in complexity of design. But it's just this sophistication that has produced non-repairable printed circuit boards, increasingly long test times, and warranty costs that undermine profits. A troubleshooting quagmire has given way in many organizations to the board exchange program where legions of spare-but-workable printed circuit boards await their fallen brethren because the boards are not field repairable.

It would seem that an integrated 8-input NAND gate should be easier to test than the comparable circuit of discrete components. But the problem with the integrated NAND is *simultaneity*—the troubleshooter has to worry about nine things at a time. In the discrete



Having internal nodes can assist troubleshooting digital circuits. With IC's, only inputs and outputs are accessible.

implementation, single leads may be individually tested. But for the IC, when you have signals flying by at megahertz rates, how does one tell whether the NAND is inoperative or that eight high inputs never occurred at the same time? The answer: multi-pin, in-circuit, digital IC testing. The troubleshooting aids on the following pages should relieve many of the frustrations inherent in finding the bad IC on a complicated printed circuit board.

A new era begins

The IC Troubleshooters are a new breed of test equipment designed specifically for in-circuit digital testing. In-circuit testing implies exercising the IC in its own environment whether using the circuit's normal stimulus or providing a new stimulus directly where it is needed. The IC Troubleshooters, singly or combined into kits, are unique in their ability to isolate problems to a node and then to analyze failures for their cause.

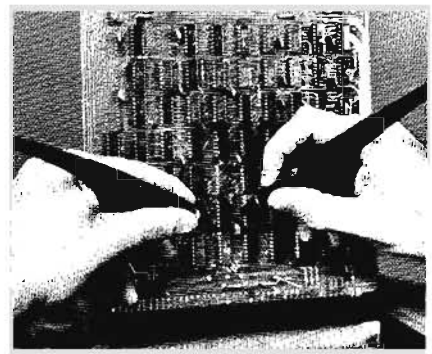
Some very perplexing troubleshooting challenges are simplified by the IC Troubleshooters. The feedback loop problem, where an error propagates back on itself through a succession of IC's, presents a tedious problem to even the most experienced troubleshooter. As the number of IC's in the loop increases, fault isolation by signal tracing becomes forbiddingly difficult. Yet this is where the 10529A Logic Comparator excels: it looks for the outputs expected from the given inputs *whether or not the inputs are correct.*

10529A Logic Comparator—an in-circuit IC functional tester.

Stimulus-response in-circuit testing

Until now this valuable technique has been denied the digital troubleshooter by low impedance output circuits which thwart arbitrary signal injection between gates. The 10526T Logic Pulser, however, injects a single 300-nanosecond pulse anywhere in TTL and DTL circuitry. The proper polarity pulse is always provided: high-going into low nodes and low-going into high. Sufficient drive capability allows "teeing" to check operation of multiple input gates.

How should one look for injected pulses in-circuit, or for pulse activity in



10526T Logic Pulser and 10525T Logic Probe combine for digital stimulus-response in-circuit testing

general? A large percentage of IC failures result from open bonds; the oscilloscope is a natural tool since lack of pulse activity is displayed by a flat trace. But for this simple but so often encountered malfunction the 10525 series of Logic Probes is really the answer. With the indicator at the troubleshooter's fingertips, a flashing light indicates pulse activity or a single flash, on or off, indicates a single pulse, even in the low nanosecond range. See the following pages for the 10525 Probe with the right spec's for your logic.

The 10528A Logic Clip is a multi-pin in-circuit tester. Sixteen bright LED's tell you the instantaneous states of all pins on 14 and 16-pin DIP's. Another valuable—and new—troubleshooting technique combines Clip and Pulser on sequential circuits. The Pulser can provide the stimulus signal such as clock, shift, preset, clear, transfer, and count, while the Clip monitors all the outputs.

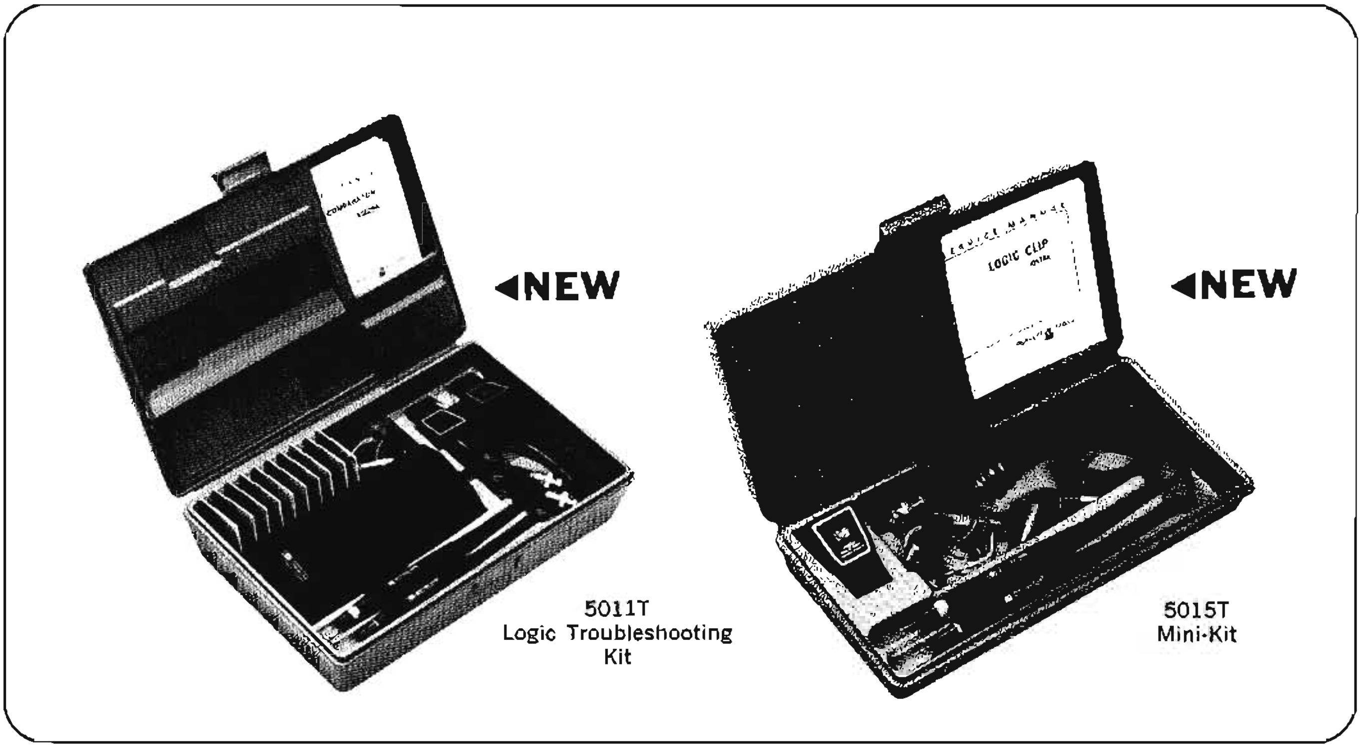
10528A Logic Clip combines with Pulser for sequential circuit test.

The IC Troubleshooters are low-cost, hand-held instruments. But don't let size and price fool you, the IC Troubleshooters are rugged and trouble-free. And most importantly, they fit the problem.

THE IC TROUBLESHOOTERS

Total solution for IC logic testing

Models 5011T, 5015T Logic Troubleshooting Kits



Model 5011T Logic Troubleshooting Kit

- In-circuit analysis
- Dynamic and static testing
- Multi-pin testing and analysis
- Complete TTL and DTL troubleshooting kit
- Stimulus-response capability
- In-circuit IC fault finding

The HP 5011T Logic Troubleshooting Kit combines all the troubleshooting capability of the four instruments described in the following pages.

These instruments, the 10529A Logic Comparator, the 10526T Logic Pulser, the 10525T Logic Probe, and the 10528A Logic Clip, have been designed to work together to detect in-circuit logic failures and to analyze failures for their specific causes. Using them you will quickly derive savings of troubleshooting dollars while repairing IC logic boards more easily than ever before.

The Logic Comparator attaches to 14- and 16-pin dual in-line TTL and DTL circuits—both sequential and combinatorial logic are testable. The IC under test is allowed to operate normally while its outputs are compared against a reference IC of the same type inserted in the Comparator. Should the circuit under test operate improperly, the failure is detected and displayed on the hand-held Comparator's panel. Sixteen LED's exactly pinpoint the failed node.

Once a failure has been isolated, the other test instruments can provide exacting analysis. For example, the Logic Probe will indicate if any pulse activity is present at the suspect node; the Probe's ability to detect single pulses, high or low, as narrow as 10 nanoseconds can insure the total absence of signals at the node. Placing the Logic Pulser on the suspect node with the Probe will allow detection of shorts to ground or the power supply—even the powerful burst of energy from the Pulser will not cause a pulse on a supply buss or ground.

Another analysis method employs the Logic Clip and Logic Pulser. The Pulser can be used to inject reset and clear signals directly into flip-flops, counters, decoders, etc. with the Clip attached to monitor the effects. With the system clock removed or shorted, the Logic Pulser can inject clock pulses one-at-a-time, and deviations from prescribed sequences can be observed on the Logic Clip 16-pins-at-a-time.

Applications of the IC Troubleshooters are endless and limited only by the imagination of the troubleshooter. In production, the lab, field service or wherever digital IC's are used, their ease of use will rapidly create substantial savings of test time and dollars.

Specifications, 5011T

Includes:
Model 10529A Logic Comparator
Model 10525T Logic Probe
Model 10526T Logic Pulser
Model 10528A Logic Clip

Weight: Net, 3 lb (1,36 kg); shipping, 5 lb (2,27 kg).

Options
01: Twenty extra blank reference boards for Comparator, $50.
02: Twenty preprogrammed reference boards (common TTL IC's) for Comparator, $150.
04: Multi-Pin Stimulus Kit for Pulser, $10.
05: Tip Kit for Probe or Pulser, $15.
06: Pulse Memory for TTL Probe, $25.

Price: $625 (1-4), $595 (5-49).

THE IC TROUBLESHOOTERS
Simplify digital fault finding
Model 5015T Mini-Kit, 10528A Logic Clip

Model 5015T Logic Troubleshooting Mini-Kit

- TTL/DTL troubleshooting kit
- Stimulus-response capability
- Ideal for lab and field service applications

The HP 5015T Logic Troubleshooting Kit combines the unique logic analysis capability of the 10525T Logic Probe, 10526T Logic Pulser, and the 10528A Logic Clip into a single handy kit. These three instruments allow you to greatly increase the speed and ease of your TTL and DTL IC troubleshooting.

The 5015T Kit derives value above that of the separate instruments from the complementing characteristics of its three Troubleshooters. Pulser/Probe and Pulser/Clip combinations are powerful stimulus-response teams that allow you to analyze circuits statically and dynamically on both a single and multipin basis. The benefit to you is a great increase in the efficiency of your troubleshooting time.

The 10525T Logic Probe provides an indication of logic state at your fingertips. Not only are TTL and DTL highs and lows displayed but also open circuits and bad levels are clearly shown. Dynamically, pulse trains to 50 MHz may be monitored and single pulses as narrow as 10 nanoseconds are detected. Thus the Logic Probe will quickly indicate the absence of key signals such as clock, reset, start, shift, transfer, etc.

The 10526T Logic Pulser brings you a new concept in digital troubleshooting: injecting a pulse between logic gates. With high current sinking and sourcing capability, the Pulser, once its pulse button is pressed, can drive low nodes high and high nodes low for 300 nanoseconds before returning to its high impedance off state. The selection of a high pulse or low pulse is automatic—just press the button!

The Logic Pulser may be used with the Logic Probe in many ways. Use the Pulser to inject signals at IC inputs while checking outputs with the Logic Probe. Convenient in-circuit stimulus is the key and is a capability unique to the Logic Pulser. The very high input impedances of both Pulser and Probe insure no circuit loading effects.

The 10528A Logic Clip's ability to monitor all the pins of TTL and DTL DIP's makes it extremely useful for testing flip-flops, counters, shift registers, decoders, etc. The Logic Pulser can inject clock and reset signals while the Clip allows you to see exactly how the device responds. Improper operation is immediately apparent.

This powerful combination of instruments is useful in the lab, production, field service, and in training applications or wherever lots of capability at a low price is desired. The time they save you in your digital troubleshooting will quickly recover the low cost of the kit.

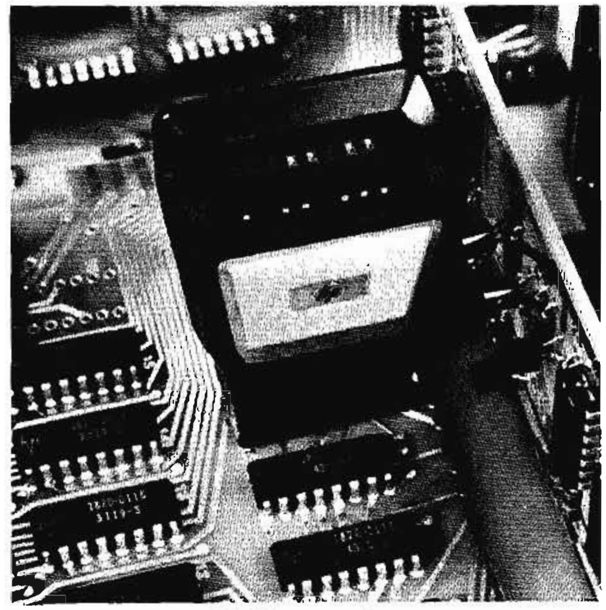
Specifications, 5015T

Includes:
Model 10525T Logic Probe
Model 10526T Logic Pulser
Model 10528A Logic Clip

Weight: net, 1 lb 6 oz (0,63 kg); shipping, 1 lb 10 oz (0,74 kg).

Options
04: Multi-Pin Stimulus Kit for Pulser, $10.
05: Tip Kit for Probe or Pulser, $15.
06: Pulse Memory for TTL Probe, $25.

Price: $285 (1-4), $250 (5-49).



10528A Logic Clip

Model 10528A Logic Clip

- Displays all states of the IC at a glance
- No power cords, no cables, just clip and observe all pins
- Compatible with TTL and DTL logic levels

16 voltmeters clipped onto a single IC? HP's Model 10528A Logic Clip is 16 binary voltmeters that attach to any 14 or 16 pin dual in-line TTL or DTL IC. An LED corresponds to each pin and lights if the pin is high or stays unlit if the pin is low. Thus all states of an IC may be viewed with a single glance. Are the input signals right? Are the outputs correct? Is the IC operating? All these questions and more are answered by the Logic Clip.

The Clip has no cables or controls. What's more it operates on any pin configuration. It automatically seeks V_{cc} and ground no matter which pins they are. The display is obvious: two rows of 8 LED's—it's like looking into the IC to see how it's operating. The intuitive relationship of the pin logic level to the light display greatly simplifies the troubleshooting procedure. You are free to concentrate your attention on your circuit rather than on measurement technique. Any way you look at the Clip, it's quite a buy at $125.

Specifications, 10528A

Input threshold: 1.4 ±0.6 V; TTL or DTL compatible (except gates with expander inputs).

Input impedance: one TTL load (—1.2 mA typical per input).

Input protection: voltages <—1 V or >7 V must be current limited to 10 mA.

General

Supply voltage: 5 V ±10% across any two or more inputs.

Maximum current consumption: 120 mA.

Temperature: 0 to 55°C.

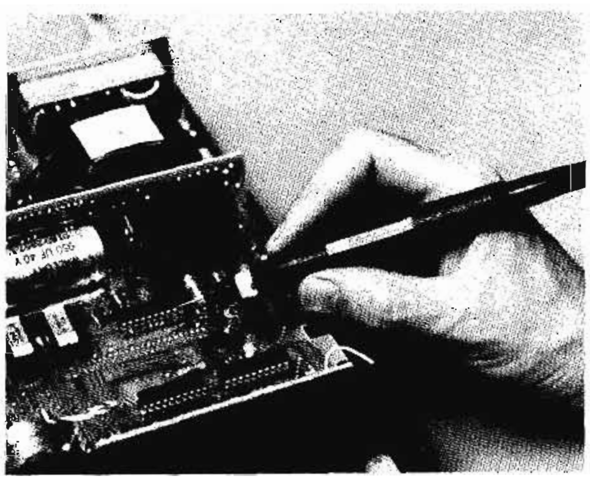
Price: $125 (1-4), $100 (5-49).

THE IC TROUBLESHOOTERS

Dynamic indicators of logic activity

Models 10525T, 10525E Logic Probes

NEW



10525T

Model 10525T Logic Probe

- Dynamic indicator of logic activity
- Pulse stretching for narrow pulses
- Bad level/open circuit detection
- No adjustments required
- Indicator at finger tips
- TTL/DTL compatible
- Safe overload protection

Using the HP 10525T Logic Probe greatly simplifies tracing logic levels and pulses through IC circuitry for logic design, maintenance checks, troubleshooting, or training. It instantly tells you whether the circuit touched is logic high, low, bad level, open circuited, or pulsing. The 10525T Logic Probe replaces the 10525A providing extra capability which was not available in the older Probe.

The 10525T Probe has preset logic thresholds of 2.0 and 0.8 volts nominal which correspond to the high and low states of conventional TTL and DTL circuits. When touched to a high level, a bright band of light appears around the probe tip; when touched to a low level, the light goes out. Open circuits or voltages in the "bad level" region between the preset thresholds cause lamp illumination at half brilliance. Single pulses of 10 ns or greater are easily viewed by stretching to one-twentieth second. The lamp flashes on or blinks off depending upon the pulse's polarity. Pulse trains to 50 MHz cause the lamp to blink off and on at a 10 Hz rate. With so much information so readily displayed it's like having an oscilloscope at your probe tip.

Using the Probe you can first run the circuit under test at normal speed while checking for the presence of key signals such as clock, reset, start, shift and transfer pulses. Next step the circuit one pulse at a time while checking the truth tables of the logic packages to turn up any defects. In this mode, combining the Probe with the 10526T Logic Pulser will greatly enhance the ease of your troubleshooting. The Pulser provides a convenient means of injecting single pulses whose effects you can monitor with the Probe.

With no adjustments needed and with an indicator at your finger tips, the Model 10525T Logic Probe frees you to concentrate on circuit troubleshooting rather than measurement techniques. Connectors provided with the Probe facilitate connection to the required 5 volt power source from either the circuit under test or a laboratory supply. A ground clip is provided with which you can directly connect the Probe circuitry to the ground of the test circuit. Shortening the ground return path results in improved noise rejection and frequency response. Model 10525T also functions quite well with logic families other than TTL and DTL, as long as the logic levels are near 2.0 and 0.8 volts.

The Probe is rugged, repairable, and warranted for one year. Its 25 kΩ input is protected against overload voltages including accidental contact with Nixie® supplies and 120 V ac.

Specifications, 10525T

Input impedance: >25 kΩ (V_{in}/I_{in} characteristic similar to low power TTL).
Logic one threshold: 2.0 V ±0.2 V.
Logic zero threshold: 0.8 V +0.2 V, −0.4 V.
Input minimum pulse width: 10 ns (5 ns typical).
Input maximum pulse repetition frequency: >50 MHz.
Input overload protection: ±70 volts continuous, ±200 volts intermittent, 120 V ac for 30 seconds.

General

Power requirement: 5 V ±10% at 100 mA.
Power supply input protection: +7 to −15 volts (includes power lead reversal protection).
Temperature: 0° to 55°C.
Accessories included: BNC to alligator clips, ground clip.
Options
005: Tip Kit, $15.
006: Pulse Memory, $25.
Price: $95 (1-4), $75 (5-49).

Model 10525E ECL Logic Probe

- Compatible with emitter-coupled-logic
- Finger tip indicator of logic levels and pulse activity
- Protected from overload voltages

The latest addition to the IC Troubleshooters is Model 10525E ECL Logic Probe for checking your emitter-coupled-logic (ECL) digital systems. Similar to its forerunners, the 10525T and H, but optimized for ECL, the Model E is faster than its predecessors and uses a −5.2 volt power supply. It detects ECL logic levels and pulses, displaying all information via a single lamp in the probe tip. Lamp indication is the same as employed by the earlier Probes: lamp on for logic ones, off for logic zeros, and flashing to indicate pulses. The Model E includes all the handy features that make its predecessors so popular. Single pulse capturing and stretching, high input impedance, and blowout-proof inputs are all included.

The 10525E thus makes available the full range of Logic Probe advantages in IC logic checkout of your ECL digital systems. The natural correlation of logic level to light indication plus finger tip display of all information will greatly aid your IC signal tracing for board repair and design debugging. The benefits of Probe usage are quick to accrue when the 10525E is put to work saving you dollars and frustration in your ECL troubleshooting tasks.

THE IC TROUBLESHOOTERS

Stimulus-response testing of digital IC's

Model 10525H Logic Probe, Model 10526T Logic Pulser

Model 10525H High Level Logic Probe

Model 10525H High Level Logic Probe brings finger tip convenience to your design and troubleshooting of systems with logic circuits in the 12 to 25 volt power supply range. With it you can immediately simplify testing of a broad range of high level circuits, including HTL and HiNIL, MOS, relay, and discrete logic.

Operation of and information displayed by the 10525H are analogous to those of the 10525T. The "H" model responds to higher input voltage levels and accepts a power supply anywhere between 12 and 25 volts. In addition, frequency response has been decreased assuring better compatibility with the types of devices that the Probe will test.

Intended for use in industrial environments, the 10525H features unmatched ruggedness and reliability. Both the probe tip and power inputs are well protected from damage due to overvoltage. The coaxial power cord is strain relieved at both ends assuring reliable connections even under extreme conditions. Reliability is further enhanced by inclusion of most of the probe circuitry into a single, custom IC which greatly reduces the component count.

Specifications, 10525H

Input impedance: >20 kΩ.
Logic one threshold: 9.5 V ±1 V.
Logic zero threshold: 2.5 V ±1 V.
Input minimum pulse width: 100 ns.
Input maximum pulse repetition frequency: >5 MHz.
Input overload protection: ±70 V continuous, ±200 V intermittent, 120 V ac for 30 seconds.

General

Power requirements: +12 to +25 V at 100 mA. Includes power lead reversal protection.
Temperature: 0 to 55°C.
Accessories included: BNC to alligator clips, ground clip.
Option
005: Tip Kit, $15.
Price: $95 (1-4), $75 (5-49).

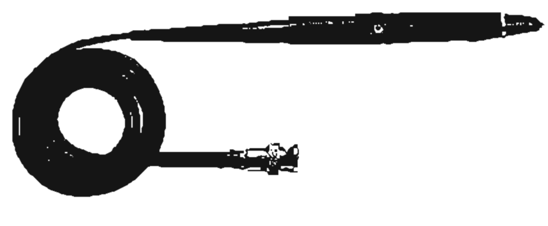
Model 10526T Logic Pulser

- In-circuit stimulation without unsoldering
- Automatic injection of proper polarity pulse
- Greatly simplifies digital troubleshooting
- Output protected against overload
- TTL/DTL compatible
- Enhances utility of Logic Probe and Clip

At last, the Model 10526T Logic Pulser solves your old design and troubleshooting problem of pulsing in-circuit IC's on TTL and DTL logic boards. Merely touch the Pulser to the circuit under test, press the pulse button and all circuits connected to the node (outputs as well as inputs) are briefly driven to their opposite state. No unsoldering of IC outputs is required. Pulse injection is automatic so you need not concern yourself whether the test node is in the high or low state: high nodes are pulsed low and low nodes, high, each time the button is pressed.

The Pulser is essentially a single-shot pulse generator with high output current capability packed in a convenient easy-to-use probe. Ability to source or sink up to .65 amperes insures sufficient current to override IC outputs in either the high or low state. Output pulse width of 0.3 μs limits the amount of energy delivered to the device under test thereby eliminating the possibility of destruction. Additionally the Pulser output is tri-state so that circuit operation is unaffected by probing until you press the pulse button.

NEW



10526T Logic Pulser

Combining in-circuit pulse injection with the unique detection capabilities of the HP 10525T Logic Probe and 10528A Logic Clip focuses new power on solving the problems of fault isolation. Pulser/Probe and Pulser/Clip combinations enable you to hold complete stimulus-response capability at your finger tips. Questions such as: "Is a gate functioning?"; "Is a pin shorted to ground or Vcc?"; "Is a counter counting?"; are quickly and easily answered without unsoldering pins or cutting PC traces.

Just inject signals into the test device with the Pulser and monitor results with the Probe and Clip. The Probe is useful when its pulse stretching capability is required, such as when testing gates and one-shots. The Clip is handy for sequential devices with multiple outputs (counters, shift registers).

Specifications, 10526T

Output HIGH pulse voltage: >2 V at .65A (1A typical at V ps = 5 V, 25°C).
Output LOW pulse voltage: <0.8 V at .65A (1A typical at V ps = 5 V, 25°C).
Output impedance, active state: <2 ohms.
Output impedance, off state: >1 megohm.
Pulse width: 0.3 μs.
Input overload protection: ±50 volts continuous.
Power supply input protection: ±7 volts (includes power lead reversal protection).

General

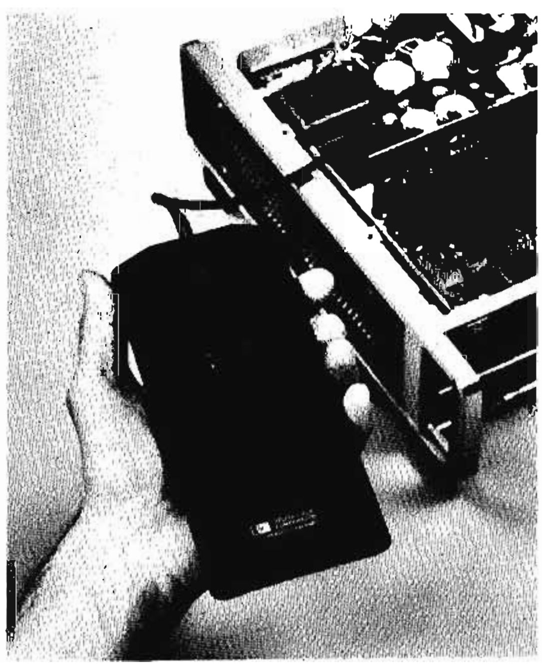
Power requirement: 5 V ±10% at 25 mA.
Temperature: 0°C to 55°C.
Accessories included: BNC to alligator clips, ground clip.
Options
004: Multi-pin Stimulus Kit, $10.
005: Tip Kit, $15.
Price: $95 (1-4), $75 (5-49).

DIGITAL CIRCUIT TEST

THE IC TROUBLESHOOTERS

In circuit IC functional tester

Model 10529A Logic Comparator



10529A

Model 10529A Logic Comparator

- Dramatically cuts troubleshooting time
- In-circuit IC testing with no unsoldering
- Simple to use with no adjustments
- Dynamic errors stretched and displayed
- Compatible with TTL/DTL logic levels
- Self-powered

The Model 10529A Logic Comparator is an extremely useful service, production, and design troubleshooting tool. This handy instrument simply clips onto powered TTL or DTL IC's and through a clever comparison scheme instantly displays any logic state difference between the test IC and a reference IC. Logic differences are identified to the specific pin(s) on 14- or 16-pin dual in-line packages with the Comparator's display of 16 light emitting diodes (LED). A lighted diode corresponds to logic difference.

The real value of the Logic Comparator is the time it can save in locating a faulty IC. There are no controls to be set, and it needs no power connections. An IC to be tested in the powered but malfunctioning module, instrument, or system is first identified. A reference board with a good IC of the same type is then inserted in the Comparator. The Comparator is clipped onto the test IC, and an immediate indication is given if the test IC operates differently from the reference IC. Even very brief dynamic errors are detected, stretched, and displayed.

The Logic Comparator operates by connecting the test and reference IC inputs in parallel; thus the reference IC is exercised by input signals identical to those of the test IC. The outputs of the two IC's respond separately and are compared; any difference in outputs greater than 200 ns in duration signals a failure.

When troubleshooting logic, it is reassuring to know that the logic tester is operating properly. A test board is supplied with the Logic Comparator for this purpose. When inserted in place of a reference board, the test board exercises all of the Comparator's circuitry, test leads, and display elements to verify proper operation.

The Logic Comparator is an unparalleled aid for locating in-circuit failed IC's. The user need not attempt to correlate readings from an oscilloscope or voltmeter with data on schematics and logic diagrams. Just clip-and-read. Functional differences are isolated precisely to the node of failure.

The Logic Comparator's ease of use and small size make it an invaluable addition to the troubleshooter's test gear either in the field or in the factory. With TTL and DTL failures that are functionally related, the Comparator can find the bad IC up to ten times faster than conventional signal tracing techniques. At its low price, the Logic Comparator can pay for itself in only days.

Specifications, 10529A

Input threshold: 1.4 V nominal, TTL or DTL compatible.

Test IC loading: outputs driving test IC inputs are loaded by 2 low-power TTL loads plus input of reference IC. Test IC outputs are loaded by 1 low-power TTL load.

Input protection: voltages <-1 V or >7 V must be current limited to 10 mA.

Sensitivity:

Error sensitivity: 200 ns. Errors greater than this are detected and stretched to at least 0.1 second.

Delay variation immunity: 50 ns. Errors shorter than this value are considered spurious and ignored.

Frequency range: with a 50% clock duty cycle, maximum frequency is typically 2.5 MHz.

General

Supply voltage: 5 V ±10%.

Maximum current consumption: 300 mA.

Supply protection: supply voltage must be limited to 7 V.

Temperature: 0° to 55°C.

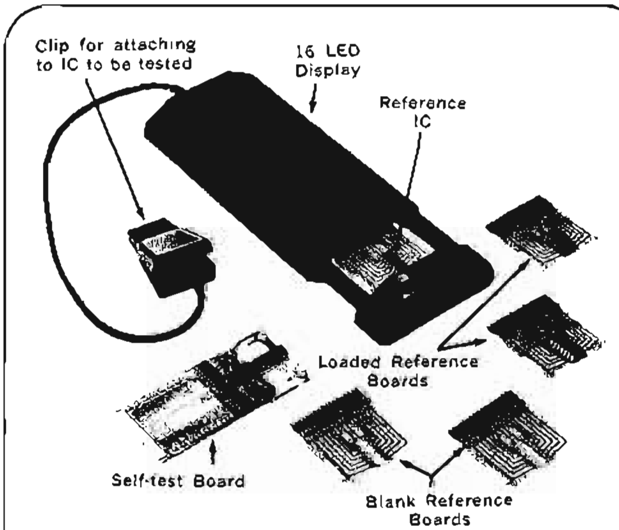
Accessories included: 1 test board; 10 blank reference boards; 1 carrying case.

Options

001: twenty extra blank reference boards, $50.

002: twenty preprogrammed reference boards (common TTL IC's), $150.

Price: $375 (1-4), $345 (5-49).

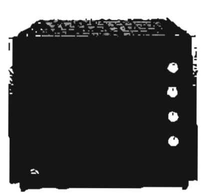


10529A

BRIGHT CRT X-Y & GRAPHIC DISPLAYS

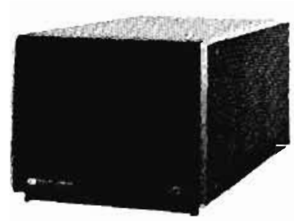
NEW▶

1331B

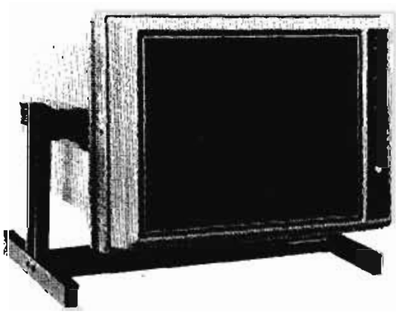


1330A

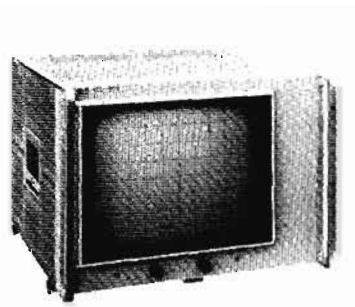
◀NEW



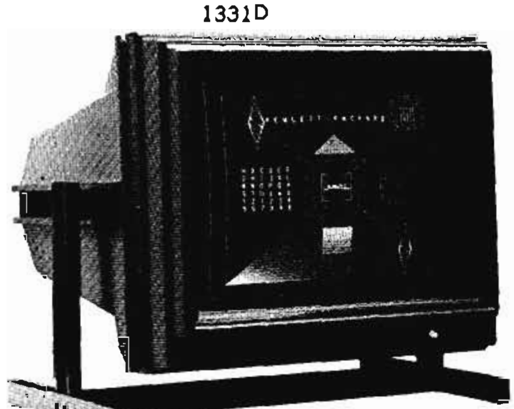
1331D



1311A



1300A



1310A

Hewlett-Packard's X-Y and graphic displays are high-performance units that provide bright, easy-to-see readouts for OEM systems. These displays are complete units with self-contained cathode-ray tube, vertical and horizontal deflection amplifiers, video (z-axis) amplifier, and high and low voltage power supplies needed for operation.

Electrostatic deflection in these graphic displays has reduced power requirements which increases life and reliability and correspondingly reduces maintenance costs. An expansion mesh, inserted in the CRT beam allows a large display size in a compact package.

Selection available

The size and type of CRT, can be selected to match your application. Standard display sizes range from 8 x 10 cm to 14, 17, or 19-inches (diagonal measurement). All displays can be adapted for free-standing (desk top) use or can be mounted in standard instrument racks or special-purpose racks.

Large screen

Models 1310A and 1311A are directed beam, high-speed 19" and 14" graphic displays with unexcelled dynamic performance. An electrostatic CRT provides a crisp, small spot which allows these displays to match speed with computer generated graphic information. The high linear writing speed of 10 inches per microsecond reduces programing complexity by allowing characters and vectors to be plotted in random fashion.

Model 1300A has a wide bandwidth of dc to 20 MHz which was developed to display analog computer waveforms and in system and lab applications. The bright, 8" x 10" viewing area gives the high resolution required in many system measurement applications.

Half-rack displays

Models 1330A, 1331B, and 1331D provide a compact display of analog computer processed data and real time information. Model 1330A has a conventional CRT and 1331B and 1331D displays have a mesh storage CRT with both variable persistance and bistable operation. The bistable mode allows a display to be stored and viewed in normal ambient light with a bright display of 100 foot Lamberts. In addition, data can be written continuously during the full one hour storage time. Model 1331B with its front panel controls, also has variable persistence and standard storage modes in addition to bistable storage. Model 1331D has rear panel controls and inputs for installation in computer or graphic display systems.

All three displays have 1 MHz X and Y bandwidths and 5 MHz z-axis bandwidth for sharp, high resolution displays in raster and directed beam applications.

Low frequency display

Models 1208A and 1208B are economical, low frequency system displays which are available in a cabinet style (1208A) and a 5¼" high rack style (1208B). The X and Y amplifiers are identical, each with a bandwidth of 600 kHz. Convenient front panel controls allow adjustment of deflection factor from 100 mV/div to 1 V/div.

Special requirements

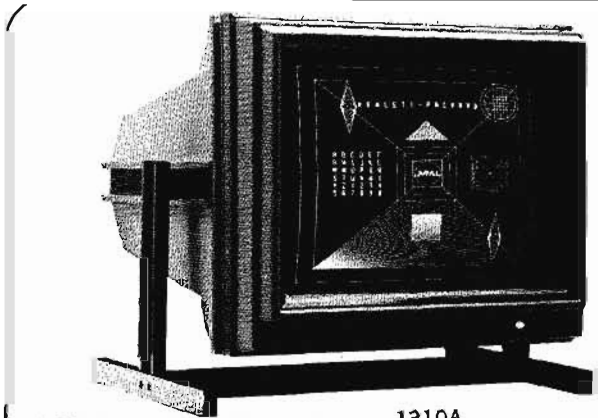
If you have special requirements for a display which is mechanically or electrically different from the standard models in this catalog, contact your Hewlett-Packard field engineer. He specializes in solving measurement problems and can help you select a special display to fit your specific requirements.

Typical changes are: modified external appearance, special graticules or phosphors on the CRT, different size CRT's, special paint to match your system, different knobs, panels, and enclosures. Electrical performance can also be changed to match your system requirements.

COMPUTER GRAPHIC DISPLAYS

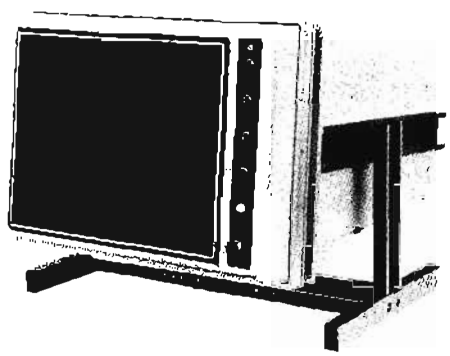
1μs Large Step Jump Time

Models 1310A, 1311A



Computer-generated graphics courtesy of The Boeing Company.

1310A



1311A

Advanced display performance

Models 1310A and 1311A are directed beam, high speed 19" and 14" graphic displays that offer unexcelled dynamic performance. For the first time, a display matches speed with computer generated graphic information. This speed is made possible through significant advances in large screen cathode-ray tube design. The electrostatic CRT provides a crisp, small spot anywhere in the large quality area of the CRT. Also, the CRT has a more rectangular shape than previous displays and information can be written anywhere in this large viewing area. Bright, easy-to-see displays result from the 28.5 kV accelerating potential while X-ray emissions are unmeasurable, ensuring a safe operating environment.

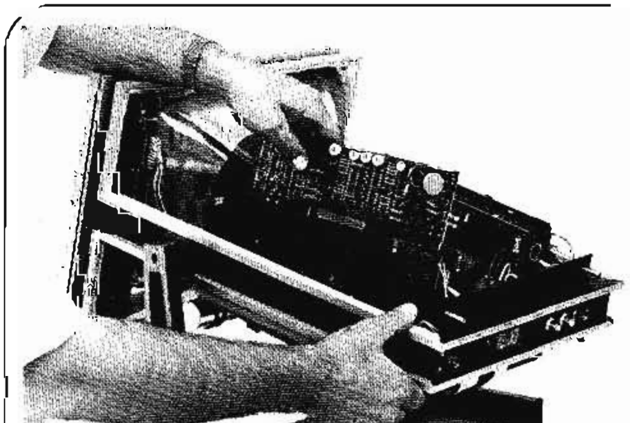
High writing speeds

Linear writing speed is an unsurpassed 10 inches per microsecond which allows character strokes to be written in less than 100 nanoseconds. Maximum slew rate of the electronics is 100 inches per microsecond. The large-step jump and settle time is 1 μs. This offers tremendous programming simplicity since characters and vectors can be plotted in random fashion from anywhere in the display area. Point plotting time for small steps is less than 200 ns per point thus, matrix type displays are written in minimal time.

Electrostatic deflection

Electrostatic deflection replaces deflection coils needed by magnetic CRTs and the high powered circuits to drive the coils. Power consumption of these displays is a scant 100 watts which eliminates noisy fans and bulky mechanical cooling assemblies. Electrostatic deflection ends the need for major and minor deflection systems with multiple input connections. The single differential input for each axis significantly reduces the effects of common mode signals. Input RC is 10 kohms shunted by 40 pF with switchable 50 ohm terminations available when required.

Internal construction is modular, rugged, and very serviceable. Plug-in circuit cards reduce calibration or trouble shooting time. Also, a board exchange program assures minimum down time since fully tested circuit boards are air-parceled from the HP parts center.

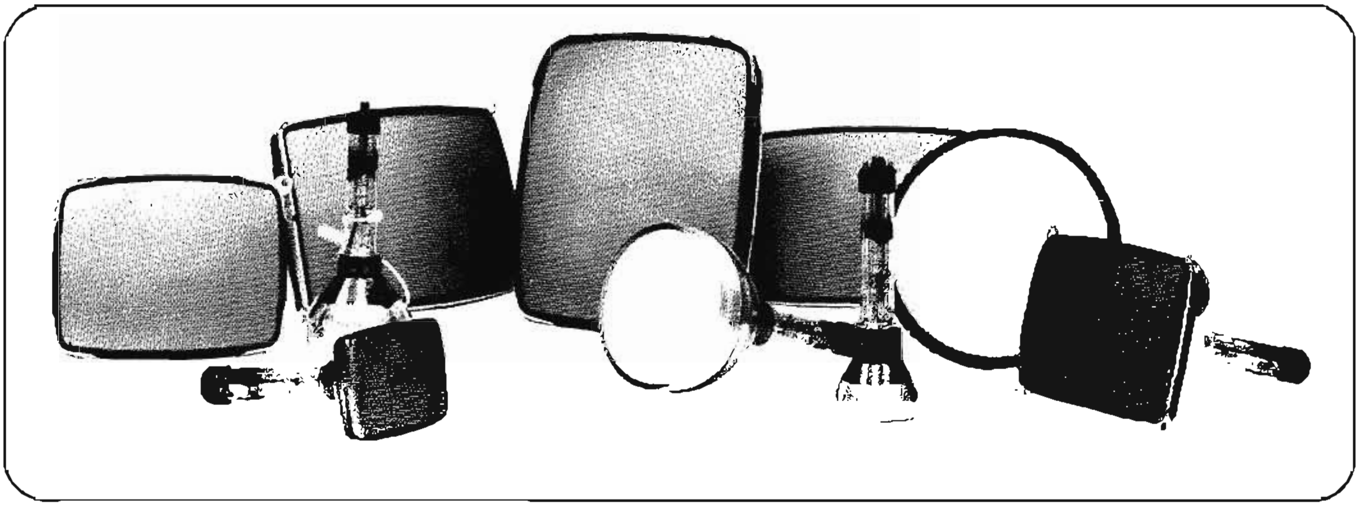


These displays are supplied with open frame construction for mounting in a standard 19-inch rack or in your custom designed enclosures. Covers and a tilt stand are available for free standing applications. Refer to Options and accessories in the specifications for listings of the standard items that are available.

COMPUTER GRAPHIC DISPLAYS

Designed for OEM systems

Models 1310A, 1311A

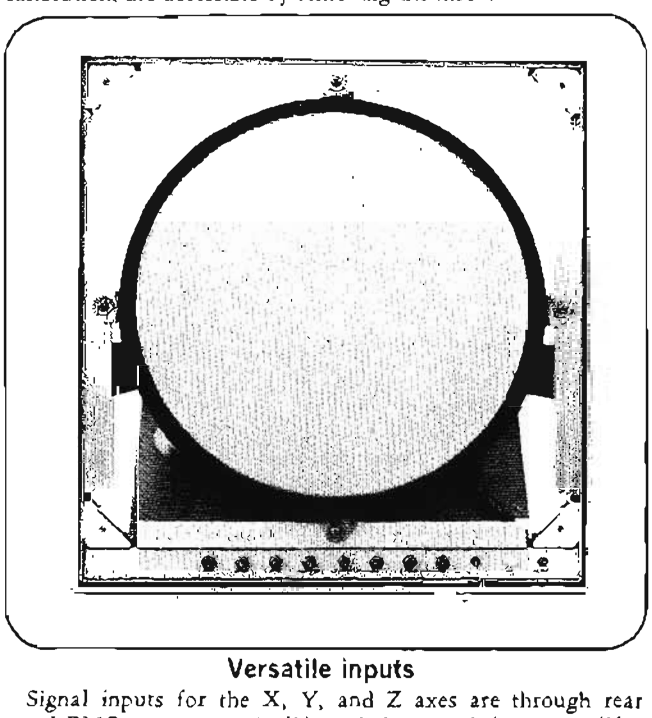


Designed for OEM systems

These high-quality, large-screen displays are designed for easy interfacing to systems requiring a visual readout. Each is a complete module with a CRT, power supplies, and analog deflection amplifiers which only require analog inputs to the X, Y, and Z axes to randomly draw dots and vectors.

Easily accessible controls

Each display has an attractive vacuum formed plastic mask that covers the front panel controls and supports an optional anti-glare contrast filter. The focus, trace align, position X, and position Y controls are accessible as screwdriver adjustments through holes in the mask while the intensity control has a knob in front of the mask. The orthogonality, gain X, and gain Y controls, which only require access during system calibration, are accessible by removing the mask.

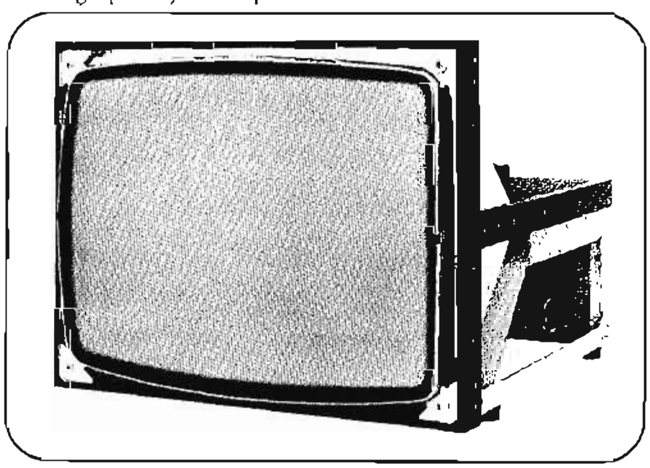


Versatile inputs

Signal inputs for the X, Y, and Z axes are through rear panel BNC connectors. A slide switch on each input amplifier allows selection of 50 ohm or 10 k ohm input impedance for easy OEM system interfacing. Inputs to the X and Y amplifiers are floating with the low side connected to ground through a 47 ohm resistor which can be easily replaced with a different resistor for true differential inputs.

A one volt input to the X or Y axes will deflect the beam full screen. Horizontal and vertical deflection factors are adjustable through a front panel adjustment. Deflection polarity can also be easily changed to match system requirements by simply reversing the CRT neck pin leads from each output amplifier.

The one volt input to the Z-axis amplifier (also called video input) unblanks the beam, which can be adjusted over a 2.5:1 range by the gain control on the Z-axis amplifier. A polarity reversal switch on the Z-axis amplifier allows fast interfacing to the graphic system input.



Special displays

The built-in flexibility of the 1310A and 1311A package design permits special mounting configurations and many different size CRT's as shown. The cathode-ray tubes, pictured here, range in size from 8-inches to 23-inches (diagonal measurement). The photos of a 21-inch rectangular CRT and 19-inch round CRT are representative of the mechanical design flexibility and CRT mounting configurations. If your graphic display system requires a special CRT or mechanical configuration, contact your Hewlett-Packard field engineer for information.

COMPUTER GRAPHIC DISPLAYS

10 in./μs Writing Speed

Models 1310A, 1311A

Specifications, 1310A, 1311A

Vertical and horizontal amplifiers

Risetime: 70 ns, 10% to 90% points for full screen deflection or less.

Bandwidth: dc to 5 MHz (3 dB down at 5 MHz) with 3.5 in. deflection in 1311A and 5 in. deflection in 1310A.

Phase shift: <0.1° to 50 kHz and <1° to 250 kHz for full screen signals.

Linear writing time: <100 ns/inch.

Linear writing speed: >10 inches/μs.

Diagonal settling time: signal settles to within 1 spot diameter of final value in <1 μs for any on screen movements.

Sequential point plotting time: signal settles to within 0.01 in. of final value in <200 ns for any 0.1 in. step.

Repeatability: <0.15% of full screen error for re-addressing a point from any direction on screen.

Crosstalk: <0.015 inch with one input shorted and the other input excited by 500 kHz.

Deflection factor*

Model	Vertical	Horizontal
1310A	1 volt for 11 in. deflection	1 volt for 15 in. deflection
1311A	1 volt for 8½ in. deflection	1 volt for 11 in. deflection

*Horizontal and vertical deflection factors adjustable from front panel control with attenuation of 1.75:1.

Spot jitter and motion: <0.015 inch.

Position: zero input can be set to any on screen position.

Polarity: positive vertical input moves beam up; positive horizontal input moves beam right. Polarity can be reversed by changing internal lead connections.

Input RC: driven side 10 k ohms shunted by <40 pF. Shield input is 47 ohms to ground. This can be replaced with 10 k ohms for differential input. A switchable 50 ohm termination between shield and center conductor is also provided.

Maximum input: ±50 V (dc + peak ac) with 10 k ohm internal termination ±5 V (dc + peak ac) with 50 ohm internal termination.

Linearity: 1% of full scale display along major axes.

Drift: 0.05 in./hr and 0.10 in. in 24 hr with covers installed.

Z-axis amplifier

Risetime: <14 ns.

Sensitivity: 1 V provides full blanking or intensity.

Input polarity: internal switch selects polarity (switch is normally set so negative voltage unblanks signal).

Gain adjust: internal, adjustable over 2.5:1 attenuation ratio.

Balance: internal adjustment provides ±1 V offset.

Input RC: approx 10 k ohms shunted by approx 60 pF. 50 ohm termination may be selected with internal switch.

Maximum input: ±50 V (dc + peak ac) with 10 k ohm internal termination, ±5 V (dc + peak ac) with 50 ohm internal termination.

Cathode-ray tube

Viewing area: Model 1310A (19 in.), 11 in. high, 15 in. wide; Model 1311A (14 in.), 8½ in. high, 11 in. wide.

Type: post-accelerator, 28.5 kV accelerating potential, P31 aluminized phosphor is standard (refer to options for other phosphors). Electrostatic focus and deflection.

Resolution: 67 lines/inch using shrinking raster method.

Brightness: at least 50 ft-L. measured at 0.1 in./μs, 60 Hz rate, with spot size of 0.020 in. in 1310A and 0.015 in. on 1311A.

Contrast ratio: 4:1 or greater.

X-ray emission: CRT emission not measurable, with Victoreen Model 440RF/C, in background noise.

Spot size

Model	Spot Size in Quality Area	Size of Quality Area
1310A	0.020 inch	11" x 11"
1311A	0.015 inch	8½" x 8½"

Implosion protection: rim and tension banding prevents implosive devacuation.

Phosphor protection: circuit detects absence of deflection and limits beam current. (Protection is designed for P31 phosphor).

General

Front panel controls: Knob, intensity; Screwdriver adjustments, focus, astigmatism, vertical position, horizontal position; Screwdriver adjustments (behind front panel mask), trace align, vertical gain, horizontal gain, orthogonality.

X, Y, and Z input connectors: BNC type mounted to rear panel.

Weight: Model 1310A, net 53 lb (24 kg), with covers 59 lb (26,8 kg); shipping, 71 lb (32,2 kg). Model 1311A, net 40 lb (18,1 kg), with covers 45 lb (20,4 kg); shipping, 62 lb (28,1 kg).

Dimensions: dimensional drawings are too numerous for presentation in this catalog. Contact your local HP Field Engineer for a data sheet with these drawings.

Power: 115 V ac ±10% or 230 V ac ±10%, 48 Hz to 440 Hz, maximum power 115 VA.

Environment: temperature, 0° to +55°C operating, −40°C to +70°C non-operating; Humidity, up to 95% relative humidity to 40°C; Altitude, up to 15,000 ft. operating; up to 25,000 ft, non-operating; Shock, 30 g level with 11 ms duration and ½ sine wave shape; Vibration, vibrated in three planes for 15 min. each with 0.010 inch excursion, 10 to 55 Hz.

Price (OEM discounts are available.)

Model 1310A: 19-inch Display . $3000.

Model 1311A: 14-inch Display . $2875.

Accessories supplied: rack mount adapter kit, front panel mask.

Options (order by option number)

003: top and bottom covers with tilt stand, add $100. (Rack mount adapter not supplied with Option 003 instruments.)

005: neutral-density contrast screen improves trace contrast for easier viewing. Add $40 for 1310A or $30 for 1311A.

006: blue contrast filter with anti-glare coating, add $40. For 1310A and 1311A add $30.

604: P4 aluminized phosphor in lieu of P31, no charge.

607: P7 aluminized phosphor, with amber filter, in lieu of P31, add $40 for 1310A, add $30 for 1311A.

639: P39 aluminized phosphor in lieu of P31, no charge.

Accessories

Cover kits: field installation of top and bottom covers. For stand alone operation, a tilt stand is required since the covers are not designed to support an instrument.

Price: Model 1310A Cover kit (HP P/N 01310-68703) $60.

Price: Model 1311A Cover kit (HP P/N 01311-68703) $60.

Tilt stand kits: field installation of tilt stand for stand alone operation. Price, Model 1310A Tilt Stand kit (HP P/N 01310-68702) $50; Price, Model 1311A Tilt Stand kit (HP P/N 01311-68702) $50.

Rack mounting kits: rack mounting adapter kits are supplied with standard instruments on initial order or may be ordered later as a kit. Price, Model 1310A Rack Mount Adapter kit (HP P/N 01310-68701) $10; Price, Model 1311A Rack Mount Adapter kit (HP P/N 01311-68701) $10.

Chassis slide kits: fixed slides, HP P/N 01310-68704 for 1310A or HP P/N 01311-68704 for 1311A, Price $100; pivot slides for 1311A only, HP P/N 01311-687505, Price $120.

Display cable, Model 10488A

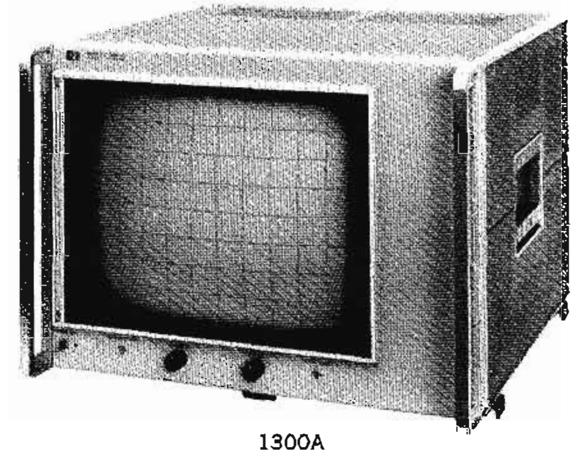
Model 10488A is a 12 ft cable with three color coded coaxial cables inside a shielded jacket. Each end has three male BNC connectors that permit connection of the X, Y, and Z inputs to the system. Price, $50.

LARGE SCREEN DISPLAY
20 MHz, 8 x 10 in. screen
Model 1300A

Description, 1300A

The extremely wide dc to 20 MHz bandwidth of the Model 1300A X, Y, and Z amplifiers provide capabilities for displaying both alphanumeric and graphic data as well as analog system monitoring. An 8 x 10-inch viewing area with a bright display provides high resolution readouts needed for many system measurement applications.

Fast 20 ns risetime, 200 ns settling time, and 80 ns point plotting time allow rapid switching of input data without flicker. This, coupled with less than 0.15% repeatability error and 1% linearity, provides accurate, stable graphic displays even with several unsynchronized multiplexed inputs. Resolution and plotting speed is such that 2000 well defined characters may be written within the 8 x 10-inch viewing area in 40 rows of 50 columns.



1300A

Specifications, 1300A

X-Y amplifiers

Bandwidth (8-inch reference at 50 kHz): dc-coupled, dc to 20 MHz; ac-coupled, 2 Hz to 20 MHz.
Risetime: <20 ns (10% to 90% points).
Deflection factor: at least 0.1 V/in.; gain control allows deflection factor to be adjusted between approx 0.1 V/in. and 0.25 V/in.
Drift: <0.5% of full screen/hr after ½ hr warmup; <1%/8 hr.
Jitter and movement: <0.01 in.
Settling time: (jump scan time) <200 ns to within a trace width of final value for any on screen movement.
Repeatability: <0.15% error for re-addressing a point from any direction from a source impedance of <4 k ohms.
Input RC: 1 megohm shunted by approx 20 pF.
Input: single-ended: maximum input ±500 V (dc + peak ac).
Linearity: over 8 x 10-in. screen, ±1% of full screen; any in. with respect to any other in., within 10%. Includes geometric distortion caused by pincushion, symmetry, and orthogonality.
Phase shift: 0.1° to 50 kHz, up to 100-inch signal; 1° to 1 MHz, up to 10-inch signal.
Cross talk: 40 dB at 20 MHz with full scale input signals; imperceptible below 5 MHz.

Z axis amplifier

Analog input: dc to 20 MHz bandwidth over the 0 to 1 V range; +1 V for full blanking, −1 V for full intensity; gain control allows deflection factor to be adjusted between approx 0.1 V/in. and 0.25 V/in. balance adjustment allows intensity reference level adjustment of ±1 V, maximum input ±500 V (dc + peak ac): differential delay with either X or Y amplifier, ±2 ns.
Rise time: <20 ns (10% to 90% points).
Sweep blank input: digital dc blanking with <1 k ohm source and −0.7 V to +5 V; unblanking with >20 k ohm source and 0 V to −5 V. Repetition rates to 1 MHz.
Chop blank input: ac-coupled blanking, +50 V blanks CRT. Input grounded when not in use.
Calibrator: line frequency square wave of 0.5 V ±2%.

Cathode-ray tube

Viewing area: 8 x 10-inches.
Accelerating potential: >20 kV.
Writing speed
- **Photographic:** >20 in/μs. Using Polaroid® CU-5 camera and 3000 speed film.
- **Visual (for 3 ft lamberts brightness at 60 Hz refresh rate):** vector, >2 inches/μs; dot writing time, 40 ns.

Sequential point plotting time: <80 ns for 3 ft lamberts brightness at 60 Hz refresh rate.
Brightness: 30 ft lamberts line brightness at 0.1 inch/μs refreshed at 60 Hz rate.
Spot size: <30 mils throughout 8 x 10-inch screen at 30 ft lamberts light output; nominally 20 mils at center screen (shrinking raster).
Phosphor and graticule: aluminized P31 phosphor with 1-inch grid and 0.2-inch subdivisions on major axis of internal graticule. Other phosphors are available, refer to Options; other graticules are available on special order. A light green filter supplied with Model 1300A provides increased contrast.

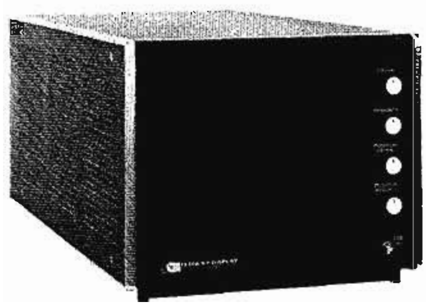
Control and input locations

Front panel: intensity, focus and on-off switch. Astigmatism and trace align are recessed screwdriver adjustments.
Rear panel: X-Y-Z inputs, calibrator, X-Y gain, position and ac-dc input switches, Z axis gain and balance.
Dimensions: 16¾" wide, 12-7/32" high, 19⅞" deep over-all 18½" behind panel rack mount (425, 310, 505, 470 mm).
Weight: net, 45 lbs (20,41 kg); shipping, 66 lbs (29,94 kg).
Power: 115 V or 230 V ±10%; 48 to 440 Hz; approx 175 W.
Price: Model 1300A, X-Y monitor, $2400. OEM discounts are available.
Options (order by option number)
- **001:** neutral density contrast filter with light transmission of ≈30%, add $15.
- **002:** P2 aluminized phosphor in lieu of P31, no charge.
- **004:** P4 aluminized phosphor in lieu of P31, no charge.
- **007:** P7 aluminized phosphor with amber filter in lieu of P31, no charge.
- **011:** P11 aluminized phosphor in lieu of P31, no charge.
- **631:** non-internal graticule CRT with P31 aluminized phosphor, add $20.

Accessories
- **Anti-reflection filters:** Model 10181A, amber for P7 phosphor, $35. Model 10182A, green for standard phosphors, $35.
- **Chassis slides:** fixed slides, HP Part No. 1490-0714, $42; pivot slides, HP Part No. 1490-0718, $40.
- **Slide adapter kit:** one adapter kit required for mounting one pair of slides, HP Part No. 1490-0721, $35.

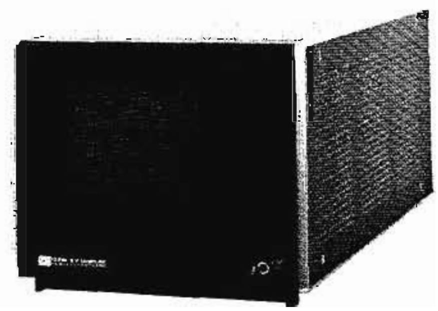
Special order
A number of special modifications are available. They include: front panel X and Y inputs and controls, X10 preamplifier for 10 mV/in X and Y deflection factors, binary Z axis to provide eight gray scales, attenuators for X and Y amplifiers. Contact your local Hewlett-Packard Field Engineer for details about these or any other special requirements you may have.

SYSTEM DISPLAYS
Graphic Displays, Bright, Bistable Storage
Models 1330A, 1331B, 1331D



1330A

1331B



1331D

Description, 1330A, 1331A, 1331C

Models 1330A, 1331A,, and 1331C Displays are compact half-rack size instruments for displaying analog computer-processed data and real time information. The high frequency response of these instruments make them extremely useful read-out devices in applications such as system display monitors, graphic displays, nuclear spectrometer, semi-conductor curve tracer, swept-frequency measurements, frequency ratios, phase shift measurements, raster displays, and amplitude versus time displays.

The 5 MHz Z-axis bandwidth provides sharp, high resolution displays in raster and directed beam applications. Differential input amplifiers on vertical and horizontal inputs reduce noise common to the inner and outer conductors of the input cables. Careful design of the solid-state X and Y amplifiers provides stable operation, long-term reliability, minimum maintenance, and low power consumption.

Storage displays

Model 1331B has front panel controls for convenient manual operation of X-Y position and storage or variable persistence controls where spot deflection and dot writing speed varies. Model 1331D has rear panel operating controls and remotely programmed inputs needed for computer or graphic display systems.

Variable persistence

Model 1331B writes and stores shades of gray which adds a third dimension to displayed data. Intermediate shades of gray can be obtained by providing a Z-axis signal between the −1 volt blanking and +1 volt full intensification voltages.

Burn-proof CRT

The CRT used in both displays is as burn proof as a standard CRT which allows carefree operation. This means that no special precautions are required during normal operation.

Bistable storage

A new, Hewlett-Packard developed bistable storage mode has been added to both displays. This bistable mode allows you to simultaneously store and view the display for up to one hour in normal ambient light with the bright 100 foot-Lambert display. In addition, with Hewlett-Packard bistable storage, data can be written continuously during the full one hour storage time. In bistable operation the beam is either stored full on or is not stored, thus the image is extremely uniform. Also, since the background in bistable mode is slightly illuminated the stored spot resolution becomes better than when the background is dark as in the variable persistence mode with maximum persistence.

The Hewlett-Packard developed mesh type bistable storage tube in these displays eliminates the need for memory devices to constantly refresh the display. Other advantages of this type tube which makes it ideal for system applications are: bright stored displays which allows viewing in high ambient light conditions; long life, comparable to standard CRT tube life, with no reduction in storage characteristics or brightness; and use in the storage mode does not reduce tube life.

Specifications, 1330A, 1331B, 1331D

(Unless otherwise noted, specifications apply to all models.)

Vertical and horizontal amplifiers

Bandwidth: dc to 1 MHz (3 dB down at 1 MHz).
Phase shift: <1° to 500 kHz.
Settling time: signal settles to within 1 spot diameter of final value in <1 μs, for any on-screen movement.
Deflection factor
- **Vertical:** 1 V for 8 div deflection. Internally adjustable from 0.09 V/div to 0.14 V/div.
- **Horizontal:** 1 V for 10 div deflection. Internally adjustable from 0.09 V/div to 0.14 V/div.

Common mode rejection ratio: 40 dB to 10 kHz for differential input of 3 V maximum between outer and inner coaxial input leads.
Maximum input: ±50 V (dc + peak ac).
Input: differential between center conductor and shield, shield may be grounded with internal connection. Polarity is reversible.
Input RC
- **Single ended:** 100 k ohms shunted by approx 80 pF to ground.
- **Differential:** 200 k ohms shunted by approx 80 pF.

Z Axis amplifier

Bandwidth: dc to 5 MHz; rise time, approx 70 ns.
Input RC
- **Single-ended:** 10 kohms shunted by approx 60 pF to ground.
- **Differential:** 20 kohms shunted by approx 60 pF.

Input: −1 V blanks spot of any intensity; +1 V provides maximum intensity.
Maximum input: ±10 V (dc + peak ac).

SYSTEM DISPLAY

Flicker free storage or refreshed displays

Models 1330A, 1331B, 1331D

1330A cathode-ray tube and controls

Type: mono-accelerator, 3 kV accelerating potential; P31 phosphor standard (refer to options for other phosphors).

Graticule: 8 x 10 div internal graticule. 1 div = 1 cm. Subdivisions markings of 0.2 div on major horizontal and vertical axis.

Display linearity: horizontal, <5% difference between any two div; Vertical, <5% difference between any two div.

Beam finder: returns beam to screen regardless of setting of horizontal, vertical, or intensity controls. Rear panel switch.

1331B/1331D cathode-ray tube and controls

Type: post-accelerator storage tube ≈ 10.5 kV accelerating potential, aluminized P31 phosphor.

Graticule: 8 x 10 div internal graticule. 1 div = 0.95 cm. 0.2 div sub-divisions marked on major axes.

Storage parameters

	Bistable Mode	Variable Persistence Mode (1331B)
Writing Speed	>20 div/ms	>40 div/ms
Dot Writing Time	<3 μs	<2 μs
Information Storage Rate	>250 kHz	>300 kHz
Storage Time	>1 hr	Writing Mode, >1 min. Store Mode, >15 min. Min Persistance, ≈ 0.2s
Brightness	>100 fl	>100 fl
Erase Time	≈ ls	<500 ms

Beam finder: returns beam to screen regardless of setting of X and Y position controls. Rear panel switch.

Model 1331D programmable functions (write, store, erase)

All program inputs are TTL/DTL compatible.

Input levels: high state is +2.0 V or greater, low state is +0.8 V or less for all program plug inputs. For high state = 2.4 V, I_{sink} = 0.4 mA max. For low state = 0.4 V, I_{source} is <1 mA.

Remote erase: low state for 10 μs minimum initiates erase cycle.

Remote mode transfer: high state is View Mode, low state is Write Mode.

Doting writing using mode transfer: dot may be written by transferring to Write Mode for 7 μs per dot. No degradation of View/Storage time occurs.

Erase Verify: indicates end of erase cycle. The output voltage is high approx 125 ms after start of erase cycle. Voltage then drops to low state and remains low to the end of the erase cycle. High state is 2.4 V minimum with I_{source} = 80 μA maximum. Low state 0.4 V maximum with I_{sink} = 3.2 mA maximum.

General

Input connectors

X, Y, and Z inputs: rear panel BNC.

Model 1331D program connector: Cannon Model 15P.

Power: 115 or 230 V ±10%, 48 to 440 Hz, approx 60 watts at normal line.

Weight: net, 19½ lbs (8,85 kg); shipping, 25 lbs (11,34 kg).

Price: OEM discounts are available for all models.

1331A X-Y Display	$ 800
1331B X-Y Storage Display	$1625
1331D X-Y Storage Display	$1675

Options

002 (1330A): P2 phosphor in lieu of P31 — no charge.

003: 5 MHz bandwidth X and Y amplifiers — Add $150.

007 (1330A): P7 phosphor with amber filter in lieu of P31 no charge.

011 (1330A): P11 phosphor in lieu of P31 — no charge

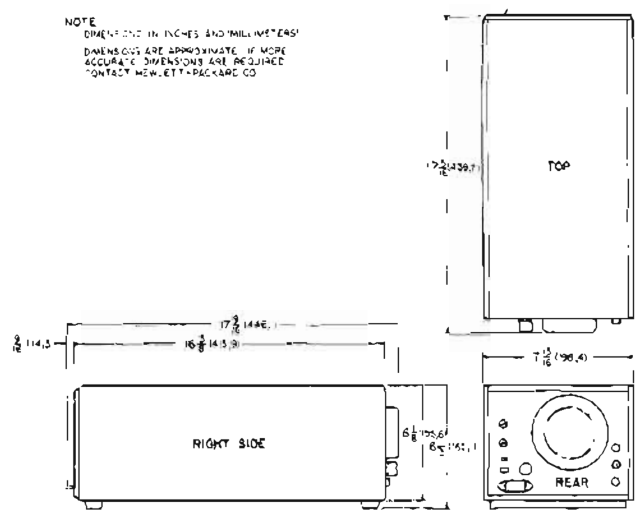
Note: beam finder intensification function is removed from Option 011 displays.

631: non-internal graticule CRT with P31 phosphor — Add $20 for 1330A and add $30 for 1331B or 1331D.

Options for 1331D

016: provides direct connection of the 1331C to a 12555A interface kit for displays using HP computers — Add $150

Dimensions:



Accessories

Display cable, model 10488A: provides interconnection between the display and the signal input source. The cable has three color-coded coaxial cables with three male BNC connectors on each end for the X, Y, and Z inputs.

Length: approx 12 ft (3.6 m).

Price: Model 10488A Display Cable — $50

Storage display cable: provides interconnection between a Model 1331D and the signal input source. The cable has connectors on each end that mate with a Cannon Model 15P connector. The cable carries X, Y, Z, and remote erase signals.

Length: approx 12 ft (3.6 m).

Price: Model 10489A Storage Display Cable — $100

Frame adapter: a 7-inch (18 cm) high panel which allows two displays to be mounted side-by-side in a standard 19-inch (48 cm) rack.

Price: Adapter Frame (P/N 5060-8762) — $25

Filler panel: covers half of a Frame Adapter when only one display is in a Frame Adapter.

Price: Filler Panel (P/N 5060-8760) — $7

Camera adapter: Model 10366B adapter provides mounting of a HP Model 195A, 197A, or 198A camera.

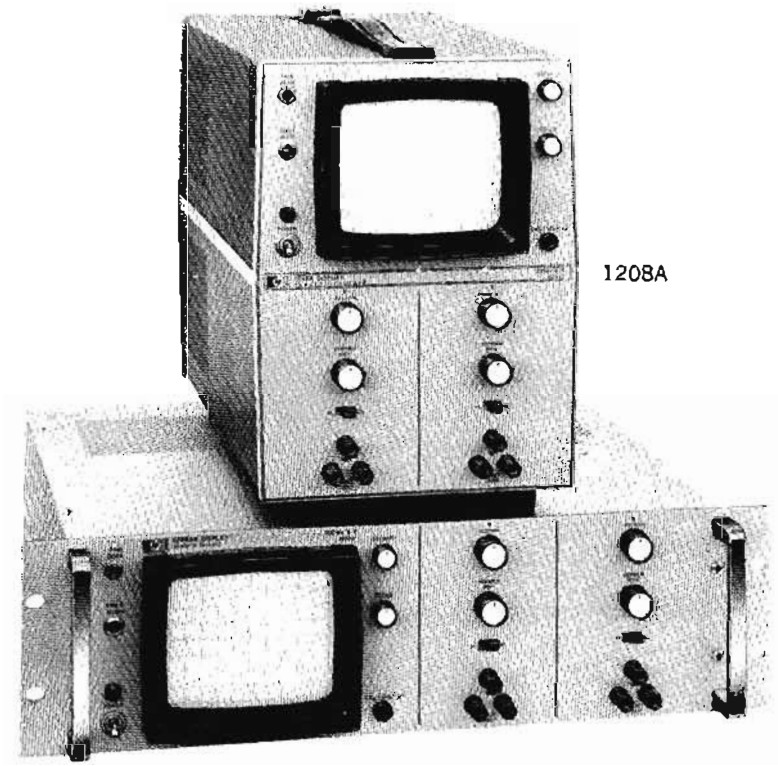
Price: Model 10366B Camera Adapter — $10

Time mark generator: the Model 226A Time Mark Generator can be used to check system linearity with external sweep inputs when a display is used in a system with analog displays. A programming option is available which would allow the 226A to be programmed into a system calibration routine.

Price

Model 226A Time Mark Generator	$670
Model 226A Programming Option 003	add $150

SYSTEM DISPLAY
5¼ in. high rack monitor
Models 1208A/B



Specifications, 1208A/B

Vertical and horizontal amplifiers

Bandwidth: dc to 600 kHz when dc-coupled; 20 Hz to 600 kHz when ac-coupled. (3 dB down from 8-div reference signal.)

Deflection factor: continuously variable from <0.1 V/div to >1 V/div.

Input: differential or single-ended.

Input coupling: front panel selection of ac or dc.

Input RC: approx 100 k ohms shunted by approx 70 pF.

Maximum input: ±200 V (dc + peak ac).

Common-mode

Rejection ratio: 40 dB (100:1).

Signal maximum: up to ±4 V (dc + peak ac).

Frequency: dc to 10 kHz.

Phase shift

Same X and Y deflection factor (with + inputs): <1° to 500 kHz for deflection factors below 0.2 V/div. <1°, to 100 kHz for deflection factors above 0.2 V/div.

Different X and Y deflection factors (with + input, − input, or differential): <3°, to 100 kHz.

Cathode-ray tube and controls

Type: monoaccelerator, 3 kV accelerating potential; P31 phosphor standard (see options for other phosphors); etched safety glass faceplate reduces glare.

Graticule: 8 x 10 divisions, internal graticule. 0.2-div subdivision markings on major axes. 1 div = 1 cm. Front panel recessed screwdriver adjust aligns trace with graticule.

Beam finder: returns trace to CRT screen regardless of setting of horizontal, vertical, or intensity controls.

Intensity modulation: +2-volt signal blanks trace of normal intensity; +8-volt signal blanks any intensity. DC-coupled input on rear panel; amplifier risetime approx 200 ns; input R is 5 k ohms.

Calibrator

Type: line frequency square wave.

Output: 1 volt ±1.5%, front panel connector (banana plug).

General

Weight

Model 1208A (cabinet): net, 21½ lbs (9,8 kg); shipping, 31 lbs (14,1 kg).

Model 1208B (rack): net, 20½ lbs (9,3 kg); shipping, 33 lbs (15,0 kg).

Power: 115 or 230 V ±10%, 48 to 440 Hz, approx 35 watts.

Dimensions

Cabinet: 8-5/17" wide, 11¾" high, 18⅛" deep (211,1 x 298,5 x 474,4 mm).

Rack: 19" wide, 5¼" high, 16⅞" deep over-all (483, 132,5, 428,6) 15⅜" (390,5) behind front panel.

Price: Model 1208A or 1208B X-Y display, $635.

Options (specify by option number)

002: P2 phosphor, no charge.

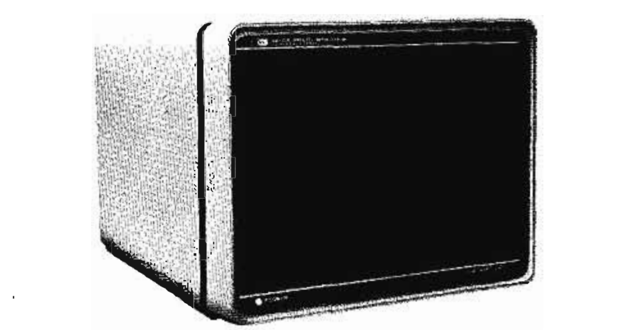
006: (1208B) rear input terminals wired in parallel with front panel input terminals. Increases input shunt capacitance to approx 120 pF. Add $55.

007: P7 phosphor, no charge.

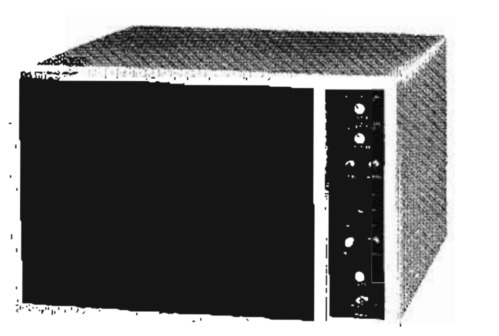
011: P11 phosphor, no charge. Beam finder intensification is removed from Option 011 displays.

Specials: special versions available with deflection factor ranges to either 5 mV/div or 100 μV/div. Consult your Hewlett-Packard field engineer for latest information.

CRT DISPLAY
Raster Display and Directed Beam Display
Models 6610A, 6947A



6610A



6947A

Directed beam display

Model 6610A is a large screen, directed beam, graphic display used to output computer and instrument generated graphic information. Extremely fine spot resolution combined with superior brightness provide a high quality, easy-to-interpret display. Available in open frame or cabinet models.

Specifications*, 6610A

Linear writing speed: >0.3 in/μs.

Diagonal settling time: beam settles to within 0.010 in. of final value in <40 μs for full screen jump scan movement.

Sequential point plotting time: beam settles to within 0.010 in. of final value in <1.2 μs for any 0.10 inch step.

Repeatability: <0.020 inch error for re-addressing a point from any position on screen. <0.010 inch crosstalk.

Deflection factor: 0.2 V/inch.

Spot jitter and motion: <0.010 inch.

Display stability, position, and size: beam will return to original position on CRT screen within 0.020 inch ±0.2% of displacement/°C when measured over an 8-hour period.

Risetime: 40 ns.

Video response: dc to 10 MHz (3 dB down).

Sensitivity: 1 volt provides full blanking or intensity. Rear panel contrast control adjustable over 6:1 attenuation ratio. Polarity reversal switch.

Input characteristics: 10 k ohms single ended (unbalanced), dc coupled, 50 ns z-axis delay matched to x-y amps.

Viewing area*: 10 in. high x 13 in. wide usable, 17 in. diagonal. Bonded CRT faceplate. P4 phosphor is standard, 0.015 in spot size.

Brightness: at least 150 ft. L measured at 0.15 in./μs, 60 Hz rate, spot size at 0.015 in., P4 phosphor.

Phosphor protection: detects beam speed and protects by overriding the z-axis.

X, Y, and Z input connectors: BNC type mounted to rear panel.

Weight: net, 85 lbs. (38,6 kg); shipping, 100 lbs. (45,4 kg).

Dimensions: open frame model, 14⅛" high, 17" wide, 27⅞" deep. (358,6 x 431,8 x 581,2 mm).

Power: 115 Vac ±10%, 208 Vac ±10%, 230 Vac ±10%; 48 to 440 Hz; 140 W average, 280 W max.

Operating temp. range: 0° to 55°C.

Price: Model 6610A Display, open frame model, $2700. OEM discounts available.

Options (order by option number)

003: rounded corner cabinet model, add $100.

004: chassis slides; for open frame model only, add $100.

*Specifications apply to 10 inch x 10 inch area. All specifications refer to temperature of 25°C ±5°C.

Precision raster display

The HP Model 6947A is a monochrome precision raster display. Special consideration is given to the display's resolution, frequency response, sweep linearity and stability.

Specifications

Input circuit: 75 ohms unbalanced to ground; 124 ohms balanced. Input impedance (unterminated): 12 K ohms.

Input connectors: BNC with loop-through facility.

Input level: 0.5 to 4 V p-p for 85-volt signal at kinescope.

Rise time: less than 40 ns for a step change input.

Input polarity: differential input; reversible polarity.

Frequency response: −3 dB at 18 MHz.

DC restoration: keyed back-porch clamp.

Field rate: vertical lock and interlace (2:1), 50 or 60 Hz field rate.

CRT: 14" diagonal. P4 phosphor, aluminized; 0.010" spot at 30fl.

Geometric raster distortion: less than 1.5% overall; less than 1% in safe title area (center 80% of full picture).

Pulse cross display: enables inspection of synchronizing information transmitted with the video signal.

Sync: composite video, 2-cable and 3-cable drive.

Ext: Sync input must be negative, from −1 V to −8 V. Separate vertical sync input must be negative, from −3 V to −5 V.

Temperature ratings: operating: 0°C to +55°C.

Controls: front-panel off-on ac switch, contrast, brightness, focus, height, width, sync, 50/60 Hz field rate switch, pulse cross display switch, and video input selector switch.

Input power: switchable between 115 and 230 Vac ±10%, 48-440 Hz; 75 W at 115 Vac.

Weight: net, 43.8 lbs. (19,8 kg); shipping 64.5 lbs. (29,2 kg).

Rack mounting: two angle brackets provided.

Dimensions: 17-1/16" (43,3 cm) W x 10½" (26,6 cm) H x 20-9/16" (52,2 cm) D.

Price: $1250.

Options

033: UHF input connectors, add $30.

034: circularly polarized laminated safety glass, add $50.

Models can be ordered with optional higher line rates.

Higher line rates (60 Hz field rate)—Add $200.

Option number	001	002	003	004	005
Lines	675	729	875	945	1029

GENERAL INFORMATION

Hewlett-Packard offers a complete line of oscilloscopes. The oscilloscopes shown in Figure 1 are representative of the wide selection available. These oscilloscopes will satisfy the requirements of almost any measurement application.

Because Hewlett-Packard is a measurement company, we know how important an accurate oscilloscope is to your job. The oscilloscope is the screwdriver of the electronics industry and has evolved into a very accurate measurement tool. Displays are larger and brighter, bandwidth has increased, sweep speeds are faster and more linear, and controls are easier to operate. In general, the most versatile of all test instruments has become even more accurate and versatile.

Hewlett-Packard has pioneered and incorporated many measure capabilities into oscilloscopes which are now taken for granted. To name a few: internal graticule CRT, beam finder, expansion mesh CRT, trigger holdoff, mixed sweep, general purpose sampling to 18 GHz, time domain reflectometry, and rugged variable persistence/storage.

Over the years, changes in measurements and scope technology have made the business of selecting, selling, and servicing scopes a bit more complex. This is where Hewlett-Packard's cumulative experience, technological leadership in many fields, and worldwide sales/service organization can be focused on your specific requirements.

Applications assistance

Solving your measurement problems is what Hewlett-Packard field engineers have built their excellent reputation on. Our field engineers attend frequent seminars which keep them abreast of latest developments. Oscilloscope application notes and technical data sheets are readily available from Hewlett-Packard.

Service and repair

Hewlett-Packard scopes are designed to perform faithfully for extended periods of time and to be easily and inexpensively serviced when required. You have the assurance that your scope will perform as expected for years to come because of Hewlett-Packard's world-wide customer service organization. Replacement parts and service assistance are available at a Hewlett-Packard field office near you.

Training aids

Training on new scopes and new applications has a high priority at Hewlett-Packard. We can help you learn more about our measurement capabilities, how to operate or use a scope, and how to properly repair or calibrate our products. In the Hewlett-Packard library of video tapes are hours of valuable information to bring you and others in your organization to almost any desired level of competence.

Figure 1. Representative oscilloscopes and displays from Hewlett-Packard's product line.

Selecting an oscilloscope

Today's selection of an oscilloscope is not as easy as it was in previous years. The recent technological changes have considerably increased the price/performance ratios that are available to you. To make the best selection, use your immediate measurement application as a starting point. Then look at your past as well as possible future measurement requirements. Then ask a few questions to reduce the number of scopes you have to look at before deciding on the best price/performance ratio.

Cathode-ray tube

Are the screen and spot size adequate? Are there photographic requirements that may require special phosphor? Do you need storage? Storage and variable persistence is very useful when observing very slowly changing phenomena, reduces photographic requirements by allowing you to photograph the trace you want, and a recent innovation provides a storage writing speed of greater than 400 cm/μs to capture elusive fast transients.

Vertical amplifier

Bandwidth and deflection factor are important points to consider. Is the bandwidth consistent through all ranges? Is the display crisp or noisy on the lower deflection factor ranges? At the same time, check the input impedance to see how much the input shunt capacitance will degrade your signal. Would a selectable input impedance be useful for both general purpose probing and 50 ohm measurements?

Trigger source

Trigger source selection increases the usefulness of a multi-channel oscilloscope. Does the scope have selection versatility to determine time delay between signals, comparison of signals with delay, or coincidence for AND and OR gates.

Time base

Time base characteristics are other points to be considered. Are the sweep speeds compatible with your bandwidth requirements? Does the time base have trigger holdoff to allow triggering on complex waveforms without losing sweep accuracy? Do you need delayed sweep, mixed sweep, or expanded sweep?

Need Special modifications?

We welcome the challenge of your special requirements in scopes. It's that simple. Whether it be a special panel paint or a substantial electrical modification, we'd like to do it for you.

Basic types of scopes

When you examine essentially all of the possible measurement requirements fulfilled by oscilloscopes, there are really perhaps only four types. In somewhat broad categories, these are: (1) plug-in/mainframe, (2) nonplug-in, (3) portable, and (4) monitor (or display). Following are some characteristics and typical applications for each type. Figure 2 shows representative scopes.

Mainframe/plug-ins

Here is where a first-order decision is usually made: Do you need plug-in capability? Mainframe and plug-ins can be selected for the combination closest to each potential application, and characteristics can be changed to accomplish varying tasks. If a mainframe is selected carefully, it will allow upgrading through newer plug-ins as they become available and as the job requires them.

General purpose laboratory scopes (i.e., mainframe and plug-ins) are used in basic circuit design for almost every electronic product. Choosing a scope to do only today's job in the lab may be unwise since its useful life will likely be diminished.

Available plug-ins might include bandwidths up to at least 100 MHz; differential/dc offset; two or four channels; standard, delayed or mixed sweep operation; sampling at bandwidths to 18 GHz; and time domain reflectometry. These give specialized measurement capability without investing in a whole new scope!

Hewlett-Packard offers such general-purpose laboratory oscilloscopes and is therefore committed to anticipating your

Table 1. Oscilloscope Selection

1300 Series X-Y Displays

Standard size CRT and large-screen X-Y or graphic displays. Both standard CRT and rugged, bistable storage/variable persistence models. Large-screen graphic displays up to a 19-inch CRT have bright traces and the speed to keep up with a computer. OEM discounts are available See Page 109

180 System High Frequency Plug-in Scope

The one plug-in instrument to solve nearly any general-purpose laboratory or production line measurement problem. Bandwidths of 500 kHz, 35 MHz, 50 MHz, 75 MHz, 100 MHz, 250 MHz, or >600 MHz. Standard, storage/variable persistence, >400 cm/μs storage writing speed or big-screen. Sampling to 18 GHz. See Page 122

1700 Series Portable Scopes

Rugged, light-weight instruments adequate for almost any field service or laboratory application. Bandwidths of 35 MHz, 75 MHz, and 150 MHz. Storage with variable persistence at 35 MHz bandwidth. Operation from ac line, dc line or source, or from an optional battery. Economically priced, too. See Page 156

140 System General-Purpose Plug-in Scope

A valued performer for Hewlett-Packard customers around the world. Standard and storage/variable persistence models and a mainframe with 8 x 10 inch display area. Real-time plug-ins to 20 MHz, sampling to 18 GHz. TDR, swept frequency, and spectrum analyzer plug-ins. See Page 167

1200 Series Low Frequency Scopes

Low frequency, non-plug-in scopes of proven, all-solid-state circuit design. Many operating features normally found only on much wider bandwidth, more expensive scopes. Bandwidths of 500 kHz or 7 MHz in standard or storage/variable persistence. Deflection factors as low as 100 μV/div. See Page 151

Oscilloscope Accessories

Supporting accessories to get the most out of your scope investment. Cameras and adapters, testmobiles, active and passive probes, and adapters to meet most any need. See Page 173

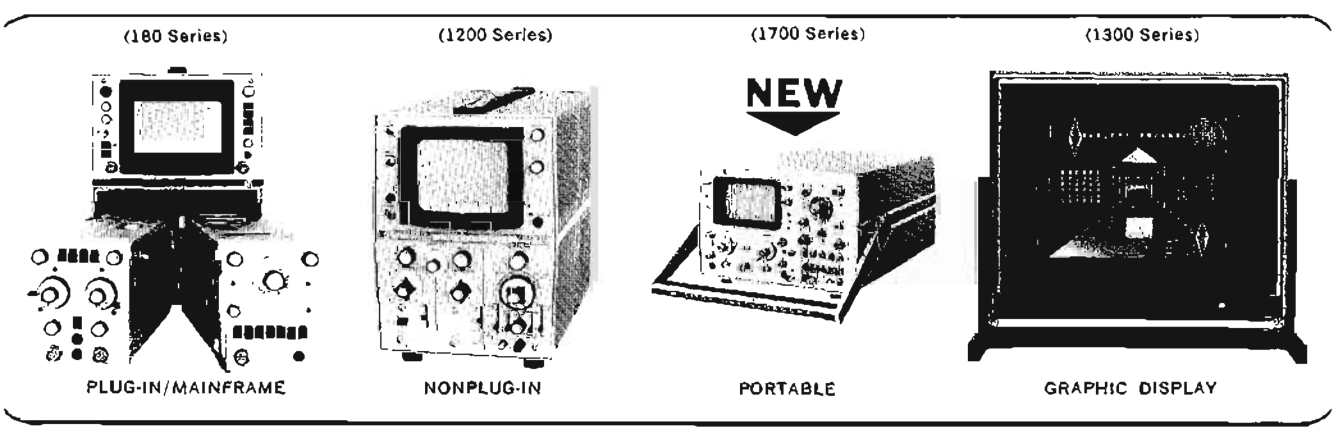


Figure 2. Hewlett-Packard scopes of four basic measurement types.

future design needs and to having the plug-ins there when you need them.

Nonplug-in

Nonplug-in scopes are frequently referred to as "dedicated." They are often dedicated to one specific task because the performance characteristics can perform that task for the useful life of the scope. As an initial investment, a nonplug-in instrument will cost less for comparable capability than a plug-in type.

By far the most common nonplug-in scopes are low frequency. Such a low frequency scope will have a bandwidth of perhaps 500 kHz (some extend to a few megahertz). High sensitivity low frequency scopes are used in applications in many different engineering and scientific disciplines.

Portables

Portable oscilloscopes are a category which usually refers to whether or not the instrument was designed to be hand-carried from one measurement location to another.

Most portable scopes are nonplug-in, with performance characteristics selected at purchase time to remain adequate for the life of the instrument. A portable scope is often used for field service work, such as maintaining a computer. However, a portable scope may still provide a good buy for design work.

Battery operation also extends to variable persistence and storage portable oscilloscopes. This provides a rugged storage tube and remote operation for your most exacting field service work.

When is an oscilloscope really portable? Carefully consider the characteristics inherent in the word portable. Obviously weight, size, and form factor enter but, also power consumption, ruggedness, and reliability must also be considered.

Hewlett-Packard has economically priced portables that meet any requirement. These portables are really portable. There is no fan required and no holes are required for convection cooling. An internal battery, ac or dc line power provides complete mobility of these instruments to allow the field measurements to 75 MHz and storage operation to 35 MHz. A metal front panel is also provided for front panel protection and allows storage of many accessories.

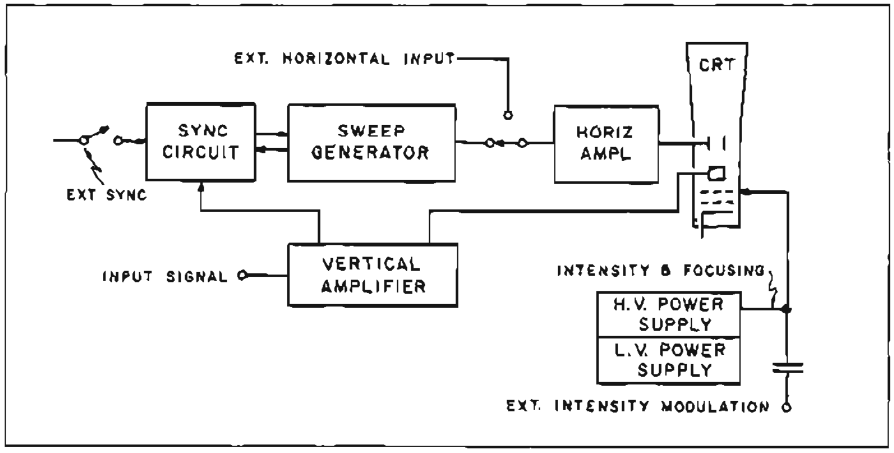


Figure 3. Typical oscilloscope block diagram.

The power required by Hewlett-Packard portable oscilloscopes has allowed very rugged instruments to be developed. These scopes, designated as 1700B Opt 300 and 1707B Opt 300 meet the requirements of the AN/USM 339 and AN/USM 338. In fact, a few modifications allowed the oscilloscope to surpass the dripproof test and operate under water. Meeting these rugged requirements did not reduce the laboratory accuracy of these instruments and they incorporate the same basic proven circuits as the standard 1700 series oscilloscopes.

Oscilloscope basics

Because the oscilloscope can display electrical signals which vary with time, it has become today's most widely used electronic measuring instrument. It produces a visual display of any physical quantity which can be represented as a voltage. This permits precise measurement and analysis of the phenomenon represented by the voltage.

The block diagram in Figure 3 shows the essential parts of an oscilloscope.

The cathode-ray tube

A CRT produces an electron beam whose movement is controlled by the vertical and horizontal amplifiers and by the power supplies which form, shape, and accelerate it. This electron beam strikes a phosphor screen and a visible glow results as the beam is moved.

Since the beam deflection can be calibrated against a grid (graticule) on the CRT face, amplitude and time measurements can be made. All Hewlett-Packard graticules are internal and in the same plane as the phosphor, eliminating parallax.

Hewlett-Packard manufactures all its own CRT's and technological leadership has accompanied this.

An expansion mesh, used first by Hewlett-Packard in 1962, with a voltage on it produces an electrostatic field which bends the beam after its initial deflection at the electron gun structure. By controlling mesh radius, Hewlett-Packard CRT designers have produced increasingly larger display areas while simultaneously reducing the over-all length of the tube.

Storage scopes are available with rugged variable persistence (the time it takes for the trace to fade to 10% of its original brightness). This is made possible by use of a storage mesh immediately behind the phosphor. Control circuits then determine the rate at which a display fades away after being stored as a charged pattern on the mesh.

Vertical deflection system

Since the CRT is limited as to the range of deflection voltages which can be applied, a vertical amplifier and attenuator are used. These are accurately calibrated to provide a deflection factor related to the graticule (e.g., 5 mV/division).

Hewlett-Packard vertical deflection systems have been made more useful with simplified, yet functional, controls. As better circuits have been designed, adjustments previously adding to front panel confusion have been eliminated or located inside for use only in periodic calibration. An example of functional and innovative amplifier design is a selectable input impedance, either 50Ω or high Z.

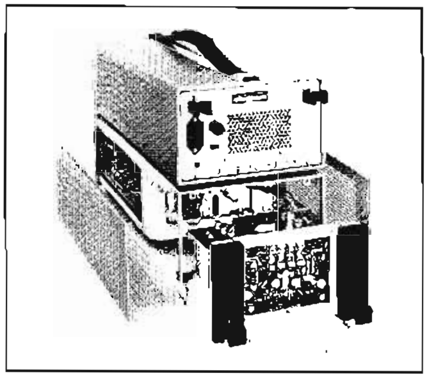


Figure 4. Power supply module can be operated outside the mainframe to facilitate maintenance.

Horizontal deflection system

To deflect the electron beam horizontally, an amplifier and sweep generator are used. A sawtooth waveform generator sweeps the beam at a selectable uniform rate. With such a linear rate of sweep, calibration to the graticule is possible (e.g., 1 ms/division).

For meaningful displays, the horizontal deflection system must provide synchronizing circuits to start the sweep at a specific instant with respect to the measured wavefom. Automatic triggering on Hewlett-Packard scopes makes starting of the sweep a quick, easy step. And preset adjustments produce synchronized sweeps with little or no adjustment. This allows stable, one-knob triggering on signals to beyond 500 MHz.

In addition to a direct-reading expander control, which minimizes errors, a time base in the HP 180 System features a X100 sweep expansion. This allows detailed examination of selected portions of a display, a feature normally found only on more expensive delaying time bases.

Power supplies

Scopes contain low and high voltage power supplies and determine, with the CRT, the maximum capability of a scope, especially of a mainframe.

Low voltage power supplies give operating power to scope circuits such as the vertical and horizontal amplifiers. The high voltage power supply forms and controls the CRT electron beam.

Hewlett-Packard has made contributions in power supplies, too, and two examples will show their significance:

1. The 1700 Series portable scopes have an advanced design LVPS. It is highly efficient and has a newly designed dc-to-dc converter. The result is a scope which consumes approximately 25 watts and operates from ac line, dc line or source, or optional battery.

2. Mainframes in the 180 System have a reliable LVPS which, when repair may be required, can be removed from the instrument in a fully operating status; refer to Figure 4. Repair or calibration time is greatly reduced.

Input probes

Proper selection of well-designed probes will minimize circuit loading effects and provide the most accurate and useful waveform information. Improper matching of probe to circuit measurement point or of probe to scope will cause risetime errors in pulse measurements and cause both amplitude and phase errors in CW measurements.

The effects of resistive loading have been recognized for some time. High input impedances have been used to reduce the voltage division between circuit and measuring device. This technique will cause minimal error if measurements are at low frequencies and the circuit test point has a low impedance.

When these probing requirements are not met, inaccuracies result for one big reason: CAPACITANCE. And the effects of capacitance in the probe or scope input change drastically because of frequency.

Hewlett-Packard has pioneered in helping solve the capacitance problem in high frequency measurements by providing selectable input impedance—50 ohms or a high Z with low capacitance. This measurement convenience is available because of Hewlett-Packard's innovative design, illustrated in Figure 5, that uses thick-film attenuators, a first, for the scope industry.

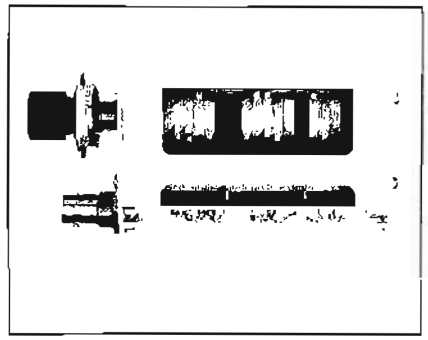


Figure 5. Hewlett-Packard innovation uses thick-film substrate in cam-operated attenuators, allowing selection of 50Ω or high input impedance with low capacitance.

Sampling oscilloscopes

Sampling oscilloscopes use a technique which is similar in principle to use of a stroboscope for study of periodic or varying motion.

Samples are taken on successive recurrences of a waveform. As each amplitude sample is taken later in time on the waveform, the CRT beam is deflected to the corresponding point where a visible dot is then displayed. The rate at which sampling occurs is very fast; thus the dots are displayed as a coherent-appearing waveform on the CRT. Figure 6 illustrates the sampling technique.

Samples are obtained when a pulse "turns on" the sampling circuit for an extremely short time. During this interval the input waveform amplitude is measured, the samples are then effectively "stretched" in time, and amplified at relatively low bandwidths.

Thanks to fast-switching diodes developed by Hewlett-Packard—some even for use in other types of instrumentration—sampling scope bandwidths have progressed to the 18 GHz point. Hewlett-Packard introduced the first commercially available sampling scope over ten years ago. Once again, cumulative technology has kept Hewlett-Packard sampling scopes a leader, both in performance and price, typified by the Model 1810A, a 1 GHz sampling plug-in that is both low in price and as easy to operate as a real-time oscilloscope.

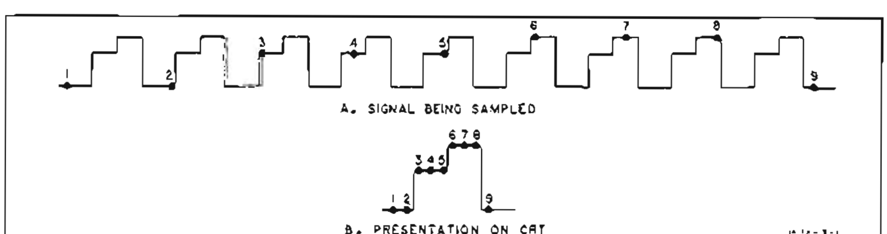


Figure 6. Sampling scope technique reconstructs waveform from consecutive samples.

GENERAL PURPOSE TO 18 GHz

Solid-state, compact, plug-in design

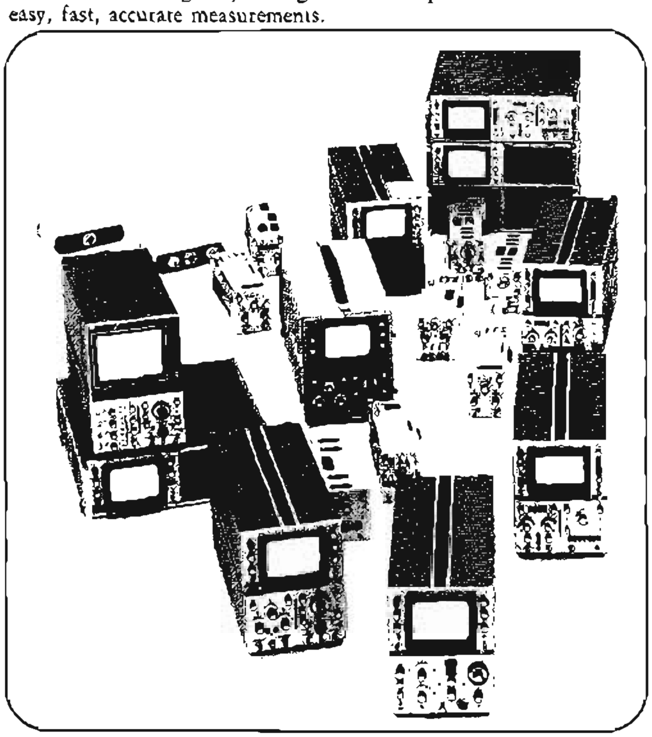
180 Series

High Standard For Oscilloscope Measurements

The growing 180 Oscilloscope System establishes the standard for high-performance, high-frequency, general-purpose oscilloscope design. This modern plug-in system allows you to match your oscilloscope capability to your particular application. These small all solid-state scopes are ideal for all types of high frequency measurements. This reliable, accurate performance has been proven in applications varying from shipboard testing, to flight-line checkout, to exacting measurements of computer memories. This system is designed to meet today's requirements and still provide capabilities for future growth.

Complete Selection For Any Measurement Need

A wide selection of mainframes and plug-ins assure you the right combination to fit a particular measurement at the minimum cost. All controls are logically arranged to allow quick familiarization for easy, fast, accurate measurements.



Mainframes

A wide selection of mainframes provides a choice of bandwidths to cover present and future needs. For measurements to 100 MHz, the 180C and 180D have bright, fast writing displays; the 181A and AR have highly burn resistant variable persistence and storage CRTS; the 184A and 184B have an extremely fast storage writing speed of 100 cm/μs and, as an option, 400 cm/μs also with a burn resistant CRT; and the 182C has a large screen display for easy-to-see multi-trace applications. Models 183A/B/C/D have bandwidths greater than 600 MHz with writing speeds of 4 and 8 ns/div for high speed pulse and CW measurements. All mainframes, except the large-screen 182C, are available in compact cabinet or 5¼" high rack styles which take little bench or rack space.

Vertical Plug-ins

The wide selection of plug-ins assures the right plug-in for almost any measurement application. To fit your application, the realtime vertical plug-in is available in 500 kHz, 35 MHz, 50 MHz, 75 MHz, 100 MHz, 200 MHz and 250 MHz bandwidths with deflection factors of 100 μV, 10 mV, 5 mV, 5 mV, 10 mV, and 10 mV, respectively. Differential/dc offset measurements are provided by the 1803A which measures offset voltages with an accuracy of 0.5%. Large signal, single-shot measurements are available in 183 mainframes in excess of 600 MHz with the direct access 1831A plug-in.

Time Bases

For accurate timing measurements, the time base plug-ins give you a choice of single, expanded, and delayed sweeps with sweep times of 5 ns/div in 180 mainframes and 1 ns/div in 183 mainframes. Applications that only require sweep expansion are provided by the 1824A at considerably lower cost than a delayed sweep time base. The 1824A not only provides an expansion of up to 100 times but it maintains the ±3% sweep accuracy that is often lost in a display magnification. If a delayed sweep is required, the 1825A provides calibrated delayed and mixed sweeps for accurate measurements. Also, by using a single reference line on the CRT, you can make differential timing measurements with approximately 1% accuracy.

Sampling Plug-ins

The new generation sampling plug-ins provide the easiest and fastest low level, high frequency measurements available at this time. The 1810A operates and looks like a real time plug-in and provides fast, accurate, low-level measurements to 1 GHz. Measurements to 4 GHz and 18 GHz are provided by the 1811A and its remote feedthru sampling heads, 1432A and 1430C. The remote sampling heads reduce measurement errors by eliminating long high frequency interconnecting lines and the feedthru characteristic allows measurements to be made while the system is operating normally with its own loads.

TDR

Time Domain Reflectometry is a fast, convenient technique of measuring the electrical characteristics of transmission systems. For wideband applications, Models 1815A/B and 1818A will display an impedance profile of a system that shows magnitude, nature, and distance of a discontinuity from the test point. Model 1818A is a low cost, easy-to-use 170 ps risetime system for installation evaluation and servicing of transmission systems. For design work or critical system installations, the 1815A/B with its remote sampling heads provides calibrated 35 ps rise times which will display discontinuities as close as ¼-inch apart.

Waveguide transmission systems can also be checked by using the 1580A narrow band TDR system. This narrow band TDR clearly shows the magnitude of discontinuities with the location directly calibrated in feet or optionally meters from the source. This allows rapid system set-up or repair of faults caused by misaligned or corroded waveguide flanges, coaxial cable connectors or damaged waveguide.

Swept frequency testing

Hewlett-Packard's Model 8755 series Frequency Response Test Sets are precision detection and display systems for making the basic microwave measurements of insertion gain/loss and return loss (VSWR) from 100 MHz to 18 GHz. The 8755L is cabinet mounted with a large screen display for bench applications; the 8755M occupies a minimum of space when rack mounted.

The 8755 system has been specifically designed to achieve a full 60 dB dynamic range when used with solid state sweepers (HP 8620 series) which typically have an output level in excess of +10 dBm. The 60 dB dynamic range from +10 all the way to −50 dB means it is possible to view a full 40 dB of return loss with couplers having a 20 dB auxiliary arm coupling factor. Refer to page 452 for specifications.

Operation in Extreme Environment

A 180 system has been developed to meet the extreme environmental requirements of the military. This system, which includes plug-ins and front panel cover with accessories, is available as an AN/USM-281A. The same ruggedized system can also be obtained as a 180F mainframe and with 1801F and 1821F plug-ins or as a rack mount model in the 180ER.

180 System Selection Charts

	MAINFRAMES	
Model No.	**DESCRIPTION**	**Price**
180C	Cabinet style for up to 100 MHz real time plug-ins	$ 950
180D	5¼-inch high rack/bench style version of 180C	1050
181A	Cabinet style, variable persistence and storage CRT, 100 MHz	1950
181AR	5¼-inch high rack/bench style version of 181A	2025
182C	Large screen, 100 MHz, cabinet style	950
183A	Cabinet style, > 500 MHz bandwidth, 4 cm/ns writing speed	1850
183B	5¼-inch high rack/bench style version of 183A	1925
183C	Cabinet style, > 500 MHz bandwidth, selectable scan, 4 or 8 cm/ns writing speed	2500
183D	5¼-inch high rack/bench style version of 183C	2600
184A	Cabinet style, 100 or 400 cm/μs storage writing speed, 100 MHz	2200
184B	5¼-inch high rack/bench style version of 184A	2275

Vertical Plug-ins

Model No.	1801A	1803A	1804A	1805A	1806A	1807A	1808A	①1810A*	②1811A	①1830A	①③1831A/B	①1834A
Bandwidth, MHz	50	40 (30)	50	100	0.5	35	75	1 GHz (sampling)	4 or 18 GHz (sampling)	250	> 600 (A) > 500 (B)	200
Min. Deflection factor/div	5 mV (500 μV Opt 001 cascaded)	5 mV (1 mV)	20 mV	5 mV	100 μV	10 mV	5 mV	2 mV	2 mV	10 mV	≈6 V	10 mV
Channels	2 (1 cas-caded)	1 diff	4	2	2	2	2	2	2	2	1	4
Differential Input	Yes	Yes (with dc Offset)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1831A only	Yes
Price	$680 (Opt 001 $830)	$1025	$1050	$1400	$675	$450	$880	$1750	$1700	$950	$375 (A) $425 (B)	$1700

Time Base Plug-ins

	TIME BASE PLUG-INS								TDR	TDR/SAMPLING	SWEPT AMP ANALYZER
Model No.	1820C	1821A	1824A	1825A	②1810A	②1811A	①1840A	①1841A	②1818A	②1815A/B	②8755A
Ext Trig	150 MHz	100 MHz	150 MHz	150 MHz	> 1 GHz	18 GHz (with countdown)	> 500 MHz	> 500 MHz	< 170 ps risetime TDR system	35 ps calibrated rise time TDR, 12.4 GHZ single channel sampling 1815A calibrated in feet 1815B calibrated in meters. Plug-in requires sampling head and tunnel diode.	Swept frequency testing from 0.1 to 18 GHZ with —50 dB sensitivity.
Int Trig	100 MHz	75 MHz	100 MHz	100 MHz	1 GHz		250 MHz	250 MHz			
Sweep Times/div	5 ns —1 s	10 ns —1 s	5 ns —1 s	5 ns —1 s	100 ps (expanded) —50 μs	10 ps (expanded) —5 μs	1 ns —0.1 s	1 ns —0.1 s			
Delayed and Mixed Sweep	No	Yes	X100 Expanded	Yes	No	No	No	Delayed			
Price	$400	$700	$550	$800	$1750	④$1700	$700	$1150	$1200	④$1250	⑤$1350

Mainframe/Vertical/Time Base Compatibility Chart

MAINFRAME		Vertical Plug-In											Time Base Plug-In						TDR/Sampling			
		1801A	1803A	1804A	1805A	1806A	1807A	1808A	1830A	1831A/B	1834A	1820C	1821A	1824A	1825A	1840A	1840A Opt 035	1841A	1810A	1811A	1815A/B	1818A
180C/D		X	X	X	X	X	X	X				X	X	X	X				X	X	X	X
181A/AR		X	X	X	X	X	X	X				X	X	X	X				X	X	X	X
182C		X	X	X	X	X	X	X				X	X	X	X				X	X	X	X
183 A/B/C/D	< 100 MHz	X	X	X	X	X	X	X				X	X	X	X				X	X	X	X
	> 100 MHz	X	X	X	X	X	X	X	X		X					X		X	X	X	X	X
	Opt 035	X	X	X	X	X	X	X	X	X	X						X					
184A/B		X	X	X	X	X	X	X				X	X	X	X				X	X	X	X

NOTES:

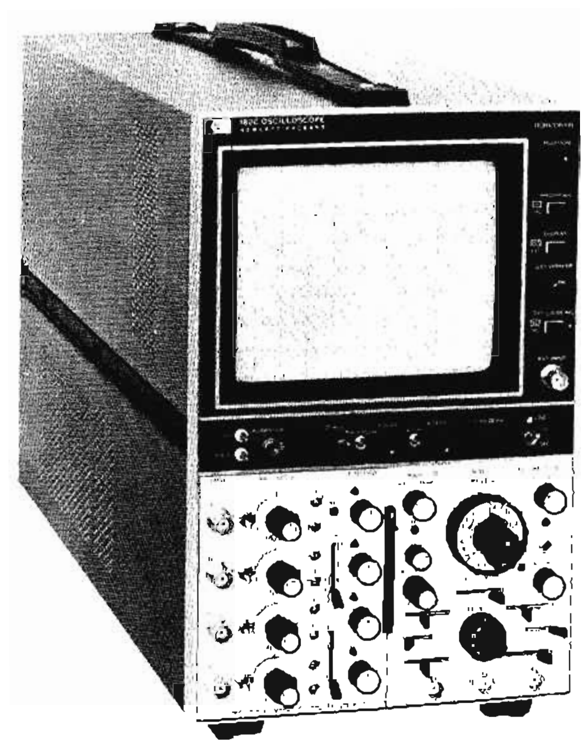
1. Operates in 183 mainframes only.
2. Double size plug-in.
3. Requires option 035 to 183 mainframes and 1840A Time Base.
4. Price is without sampling heads and tunnel diodes.
5. See page 452 for specifications.

LARGE SCREEN, 100 MHz
Plug-in flexibility
Model 182C

Description, 182C

Model 182C plug-in oscilloscope mainframe provides large screen, 100 MHz bandwidth in the proven 180 oscilloscope system. The parallax free, internal graticule is 8 x 10 divisions with each division equal to 1.29 cm, which makes it easier to view displays from a distance. This larger CRT area, 66% larger than 8 x 10 cm displays, also improves viewing of displays such as four-channel, differential/dc-offset, and time domain reflectometer measurements.

Another feature of this mainframe is its design for maintainability. Plug-in circuit modules that connect to a printed circuit mother board almost eliminate internal cabling, which increases reliability and makes it easier and quicker to get an instrument back into service. For example; the horizontal amplifier is on a plug-in circuit board that includes a section of front panel with knobs and switches mounted on it. This allows a complete, pre-tested board to be quickly installed which keeps instrument down-time to a minimum. Also, the function of major circuit areas, test points, and adjustment values are printed on the circuit boards so a knowledgeable technician can easily adjust or repair the circuits.



182C

Specifications, 182C

Cathode-ray tube and controls

Type: post accelerator, 19 kV accelerating potential; aluminized P31 phosphor (other phosphors available, see Options).

Graticule: 8 x 10 div internal graticule. 0.2-div subdivisions on major axes. 1 div = 1.29 cm. Front panel recessed screwdriver adjustment aligns trace with graticule. Scale control illuminates CRT phosphor when viewing with hood or taking photographs.

Beam finder: returns trace to CRT screen regardless of setting of horizontal, vertical, or intensity controls.

Intensity modulation: approx +2 V, ≥50 ns pulse width (≤10 MHz CW) will blank trace of normal intensity. Input R, approx 5 k ohms. Maximum Input voltage, ±20 V (dc + peak ac).

Calibrator

Type: approx 1 kHz square wave, <3 μs rise time.

Voltage: two outputs, 250 mV p-p and 10 V p-p; accuracy, ±1%.

Horizontal amplifier

External input

Bandwidth: dc-coupled, dc to 5 MHz; ac-coupled, 5 Hz to 5 MHz.

Deflection factor: 1 V/div, x1; 0.1 V/div, x10; accuracy, ±5%. Vernier provides continuous adjustment between ranges.

Dynamic range: ±20 V.

Maximum input: ±300 V (dc + peak ac).

Input RC: 1 megohm shunted by approx 30 pF.

Internal sweep

Sweep magnifier: x10; accuracy, ±5% (including 3% accuracy time base).

General

Outputs: four emitter follower outputs on rear for main and delayed gates, main and delayed sweeps or vertical and horizontal outputs when used with sampling plug-ins; maximum current available, ±3 mA; outputs will drive impedance ≥1000 ohms without distortion.

Weight: (without plug-ins) net, 26½ lb (12,02 kg); shipping 38½ lb (17,46 kg).

Power: 115 or 230 V ±10%, 48 to 440 Hz, <110 watts with plug-ins at normal line. Max. mainframe power, 200 VA.

Operating environment: temperature, 0°C to +55°C; humidity, up to 95% relative humidity at 40°C; altitude, up to 15,000 ft; vibration, vibrated in three planes for 15 minutes each with 0.010 inch excursion, 10 to 55 Hz.

Dimensions: 7 15/16 in. wide x 13 5/16 in. high x 19 5/8 in. deep over-all (201,6 x 338,1 x 498,5 mm).

Accessories furnished: blue light filter; power cord.

Price: (mainframe less plug-ins)

Model 182C Oscilloscope Mainframe	$950
Model 182C Option 010 Oscilloscope Mainframe	$900

Options

002: aluminized P2 phosphor in lieu of P31, no charge.

007: aluminized P7 phosphor in lieu of P31, no charge.

010: mainframe without rear panel main and delayed sweep and gate outputs — Less $50

011: aluminized P11 phosphor in lieu of P31, no charge. Beamfinder does not intensify display on Option 011 oscilloscopes.

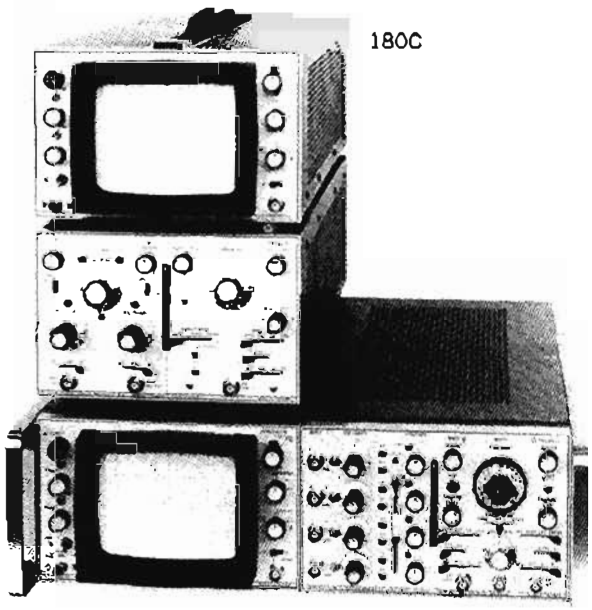
HIGH WRITING SPEED
Plug-in flexibility
Models 180C, 180D

Description, 180C/D

Models 180C (cabinet style) and 180D (rack style) mainframes contain the basic functional circuits and power supplies for real time 1800 series plug-ins to 100 MHz, TDR and 12.4 GHz sampling and dual channel 1 GHz and 18 GHz sampling plug-ins. Basic mainframe features are: 8 x 10 division (1 div = 1 cm) internal, parallax-free graticule; internal flood gun for scale illumination; x 5 and x 10 sweep magnifier; external horizontal input; two calibrator outputs of 250 mV and 10 V; and the Hewlett-Packard developed beam finder.

The cathode-ray tube has 15 kV accelerating potential for fast visual and photographic writing speeds which makes it easy to measure low duty cycle pulses. Photographic writing speed with P31 phosphor is 1500 cm/μs and is measured using an HP 195A Camera, 10,000 ASA film without film fogging techniques.

To facilitate servicing, the modular power supply may be simply unplugged and removed from the mainframe for complete access to all components. In addition, the power supply may be operated in this exposed condition without requiring separate extenders which further simplifies and speeds up maintenance procedures. A horizontal gain calibrator, Model 10411A, is available to provide fast calibration of the mainframe horizontal amplifier. This and other accessories are listed in the accessories section.


180C

180D

Specifications, 180C/D

Cathode-ray tube and controls

Type: post accelerator, approx 15 kV accelerating potential; aluminized P31 phosphor (see Options for other phosphors).

Graticule: 8 x 10 div internal graticule, 1 div = 1 cm, 0.2 div subdivisions on major axes. Front panel recessed screwdriver adjustment aligns trace with graticule. Scale control illuminates CRT phosphor when viewing with hood or taking photographs.

Beam finder: returns trace to CRT screen regardless of setting of horizontal, vertical, or intensity controls.

Intensity Modulation (External Input)

Input: approx +2 V, ≥50 ns pulse width (≤10 MHz sine wave) will blank trace of normal intensity.

Input R: approx 5 kohms.

Maximum input: ±20 V (dc + peak ac).

Photographic writing speed: 1500 cm/μs. Measured using P31 phosphor, 10,000 ASA film without film fogging and HP Model 195A camera (1.3 lens, 1:0.5 object-to-image ratio). Writing speed may be increased substantially by using film fogging techniques, P11 phosphor, and faster camera lenses.

Calibrator

Type: approx 1 kHz square wave, <3 μs rise time.

Voltage: two outputs, 250 mV p-p and 10 V p-p into ≥1 megohm; accuracy, ±1%.

Horizontal amplifier

External input

Bandwidth: dc to 5 MHz dc-coupled; 5 Hz to 5 MHz ac-coupled.

Deflection factor: 1 V/div, x1; 0.2 V/div, x5; 0.1 V/div, x10; accuracy ±5%. Vernier provides continuous adjustment between ranges.

Dynamic Range: ±20 V.

Maximum Input: 600 Vdc (ac-coupled input).

Input RC: approx 1 megohm shunted by approx 30 pF.

Internal sweep

Magnifier: x5, x10, accuracy ±5% (with 3% accuracy time base).

General

Outputs: four rear panel, emitter follower outputs provide main and delayed gates, main and delayed sweeps, or vertical and horizontal outputs when used with TDR/Sampling plug-ins. Maximum current available, ±3 mA. Output will drive impedances of ≥1000 ohms without distortion.

Weight (without plug-ins)

Model 180C (cabinet): net 24 lb (10,9 kg); shipping, 36 lb (16,3 kg).

Model 180D (Rack): net, 26 lb (11,8 kg); shipping, 40 lb (18,1 kg).

Power: 115 or 230 V, ±10%; 48 to 440 Hz; normally <110 watts with plug-ins at normal line. Max. power, 200 VA.

Operating environment: Temperature, 0 to +55°C; Humidity, to 95% relative humidity to 40°C; Altitude, to 15,000 ft; Vibration, vibrated in three planes for 15 min. each with 0.010 inch excursion, 10 to 55 Hz.

Dimensions

Cabinet Model 180C: 7⅞" wide, 11⅜" high, 21¼" deep behind panel (200 x 289 x 540 mm).

Rack Model 180D: 16 3/4 in. wide, 5 7/32 in. high, 21 3/8 in. deep over-all (425, 132,6, 543 mm), 14 3/8 in. (493 mm) deep behind rack mount tabs.

Accessories furnished: 7½ foot power cord, Model 10179A mesh contrast filter, one blue plastic light filter; rack mounting hardware and 2 probe holders (HP P/N 5050-0464) are also supplied with 180D rack model.

Price (mainframe less plug-ins)

Model 180C Oscilloscope Cabinet Style Mainframe	$950
Model 180C Option 010 (See options)	$900
Model 180D Oscilloscope, Rack Style Mainframe	$1050
Model 180D Option 010 (See Options)	$1000

Options

The following options are available to modify a mainframe to fit your application. If other mainframe changes are required, contact your Hewlett-Packard Field Engineer.

002: aluminized P2 phosphor in lieu of P31, no charge.

007: aluminized P7 phosphor in lieu of P31, no charge.

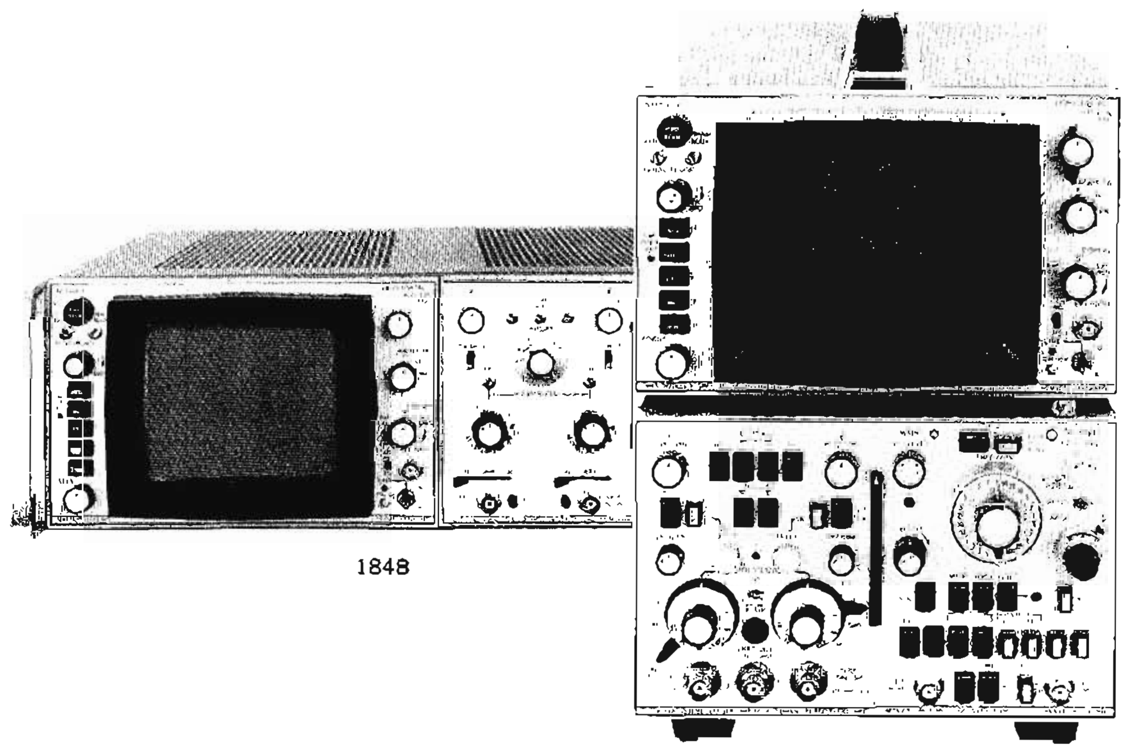
010: deletes the rear panel outputs for main and delayed gates and main and delayed sweeps — Less, $50

011: aluminized P11 phosphor in lieu of P31, no charge. Beamfinder does not intensify display on Option 011 oscilloscopes.

HIGH WRITING SPEED STORAGE

100 or 400 cm/μs, burn resistant

Models 184A, 184B



1848

184A

Description, 184A/B

The Model 184A cabinet style and 184B, 5¼" high rack style variable persistence and storage mainframes provide writing speeds of 100 or 400 cm/μs. These writing speeds are so fast that traces you previously had to photograph to see can now be viewed directly in normal ambient light. A unique FAST mode optimizes writing speed by switching the CRT display to reduced scan while maintaining full calibration and resolution. A second graticule, for the fast mode, is superimposed in the center of the screen and a front panel light indicates when the scope is in the FAST mode.

The 184 Option 005 offers an unexcelled FAST writing speed of 400 cm/μs and the standard 184 provides an exceptional 100 cm/μs. The ultra-fast stored writing speed of 400 cm/μs is fully compatable with a single-shot, 5 ns rise time transient with an amplitude of greater than 5 divisions. Combining this superior single-shot writing speed with variable persistence also provides bright clear displays of low repetition rate digital waveforms.

Advances in target material and processing provides extremely high writing speed as well as a very rugged storage surface. This highly burn resistant, high-speed storage surface does not require special operating procedures.

The fast storage writing speed of the 184 storage CRT is extremely useful for displaying single sweep or low repetition rate signals with fast rise times. This capability allows you to study a waveform or to photograph the trace with a general purpose scope camera as in Figure 1. The digital word, in Figure 1 from TTL logic is occuring at a 1 Hz rate and is integrated, using variable persistance, to a bright clear display which is easily viewed in normal ambient light. The high writing speed allows storage and display of random noise pulses such as that in Figure 1 or single shot transients as shown in Figure 2. For general purpose use where maximum writing speed is not of prime concern, a STD mode provides maximum brightness, highest contrast ratio, and largest display area (see Figure 3). A storage time control allows a trade-off of viewing brightness for storage time which makes it possible to retain a display for greater than 30 minutes in STD mode and greater than five minutes in FAST mode. Another useful storage mode is the store mode coupled with the time base set for single-sweep operation. In this mode the 184 will remain prepared to store a signal for over 30 minutes in STD mode and more than five minutes in FAST mode.

This high speed storage tube also provides the same high contrast as a conventional CRT and with a bright display of

100 MHz STORAGE MAIN FRAME
Plug-in flexibility, 18 GHz Sampling
Models 184A, 184B

100 foot lamberts in the STD mode and 50 foot lamberts in the FAST mode. Also, by modulating the Z-axis, you can easily distinguish between several trace intensities.

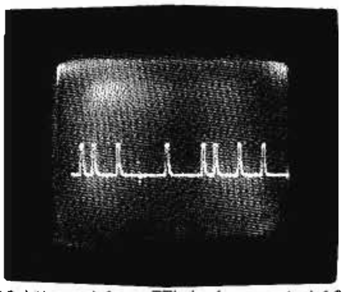


Figure 1. 16 bit word from TTL logic repeated 16 times at a 1 Hz rate. The 10 ns duration noise pulse occurs only once in 16 words.

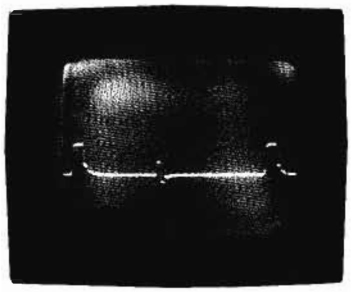


Figure 2. Single-sweep display at 100 ns/div.

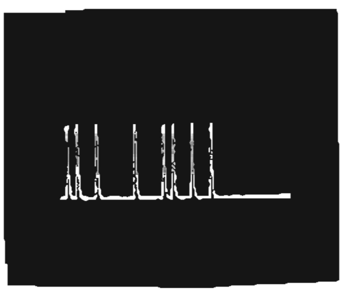


Figure 3. Digital word at 250 Hz rep rate integrated to a bright clear display in STD mode using variable persistence.

Specifications, 184A/B

Cathode-ray tube and controls

Type: post-accelerator storage tube; aluminized P31 phosphor.

Graticule: 8 x 10 div internal graticule, 0.2 div subdivisions on major axes. 1 div = 0.95 cm. 8 x 10 div internal graticule superimposed in center of normal scope graticule (for fast writing speed mode). 1 div = 0.475 cm. Front panel adjustment aligns trace with graticule.

Beam finder: returns trace to CRT screen regardless of setting of horizontal or vertical controls.

Intensity modulation: approx +2 V, ≥50 ns pulse width (≤10 MHz CW) blanks trace of normal intensity. Input R, 5100 ohms.

Writing modes: conventional (non-storage), standard and fast (variable persistence and storage). Pressing store and either STD or FAST provides maximum persistence with floodguns off for a ready-to-write state. The CRT will remain primed and ready-to-write for >30 min. in STD/STORE and >5 min. in FAST/STORE.

Persistence
- **Conventional:** natural persistence of P31 phosphor (approx 40 μs).
- **Variable:** from <50 ms to >1 min.

Storage writing mode

Model	STD Mode	FAST Mode*
184A/184B	>0.2 cm/μs	>100 cm/μs
184A/184B (Option 005)	>0.2 cm/μs	>400 cm/μs

*Calibrated area reduced to 4x5 cm.

Brightness
- **Standard:** >100 foot lamberts.
- **Fast:** >50 foot lamberts.

Storage time
- **Standard writing speed:** variable from >1 min. at normal intensity to >30 min. at reduced brightness.
- **Fast writing speed:** variable from >10 s at normal intensity to >5 min. at reduced brighness.

Erase: manual, pushbutton erasure takes approx 300 ms.

Horizontal amplifier

External input
- **Bandwidth:** dc to 5 MHz; ac-coupled, 5 Hz to 5 MHz.
- **Deflection factor:** 1 V/div in X1; 0.2 V/div in X5; 0.1 V/div in X10; accuracy ±5%.
- **Dynamic range:** ±20 V.
- **Maximum input:** 600 V dc (ac-coupled input).
- **Input RC:** approx 1 megohm shunted by approx 30 pF.

Internal sweep
- **Magnifier:** X5, X10; accuracy, ±5% (with 3% accuracy time base).

General

Calibrator
- **Type:** approx 1 kHz square wave, 3 μs rise time.
- **Amplitude:** 10 V p-p; accuracy, ±1%.

Outputs: four rear panel emitter follower outputs for main and delayed gates, main and delayed sweeps, or vertical and horizontal outputs when used with TDR/Sampling plug-ins. Maximum current available, ±3 mA. Will drive impedances ≥1000 ohms without distortion.

Weight (without plug-ins)
- **Model 184A (Cabinet):** 24 lb (10,9 kg); shipping, 40 lb (18,1 kg).
- **Model 184B (Rack):** 26 lb (11,8 kg); shipping, 40 lb (18,1 kg).

Operating environment: temperature 0 to 55°C; humidity, to 95% relative humidity to 40°C; altitude, to 15,000 ft; vibration, vibrated in three planes for 15 minutes each with 0.010 inch excursion, 10 to 55 Hz.

Power: 115 or 230 V ±10%, 48 to 440 Hz, 115 watts at normal line with plug-ins. Max. mainframe power, 225 VA.

Dimensions
- **Cabinet Model 184A:** 7⅞" wide, 11⅜" high, 21¼" deep behind panel (200 x 289 x 540 mm).
- **Rack Model 184B:** 16¾" wide, 5-7/32" high, 21⅜" deep over-all (425 x 132,6 x 543 mm), 14⅜" (493 mm) deep behind rack mount tabs.

Price

Model 184A Cabinet storage Mainframe	$2200
Model 184A Option 005 Fast storage CRT	add $ 500
Model 184B rack style storage mainframe	$2275
Model 184B Option 005 fast storage CRT	add $ 500

Accessories furnished: one Model 10178A mesh contrast filter, one blue plastic light filter (HP P/N 5060-0548), one 230 V fuse package (HP P/N 5080-9672), one 7.5 ft (1.9 m) 3-wire power cord. A rack mount kit (HP P/N 5060-8740) and two probe hangers (HP P/N 5040-0464) are also supplied with the 184B rack model.

100 MHz, STORAGE CRT
Plug-in flexibility
Models 181A, 181AR

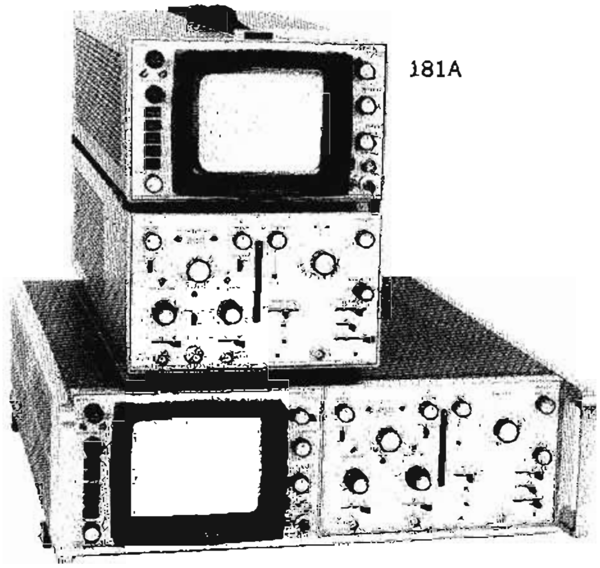
Description, 181A/AR

Models 181A (cabinet style) and 181AR (rack style) mainframes provide plug-in flexibility, 100 MHz bandwidth capability with a variable persistence/storage cathode-ray tube. The storage mesh CRT allows you to adjust the amount of time a trace is retained to match your measurement requirement. In addition, the 181 offers storage capability for over one hour to permit you to study or photograph a display at your convenience.

Variable persistence and storage is useful for displaying many types of signals, especially low repetition rate or single shot events. Variable persistence allows you to adjust the trace retention time to match your signal requirements, thus eliminating annoying slow sweep flicker.

Improvements in target material and processing provide a very rugged storage surface which resists burns. The CRT is so burn resistant that you do not require any special operating procedures.

The single shot Writing speed in the 181 is variable from 20 cm/ms to greater than 5 cm/µs. This allows adjustment of the writing speed to match the measurement requirement which provides more versatile scope operation. The integrating capability inherent in this storage CRT allows fast rise repetitive pulses to be displayed even though they may be well beyond the single shot writing capability of the CRT.



Specifications, 181A/AR

Cathode-ray tube and controls

Type: post-accelerator storage tube; 8.5 kV accelerating potential; aluminized P31 phosphor.
Graticule: 8 x 10 div internal graticule, 0.2 div subdivisions on major axes. 1 div = 0.95 cm. Front panel adjustment aligns trace with graticule.
Beam finder: returns trace to CRT screen regardless of setting of horizontal or vertical controls.
Intensity modulation: approx +2 V, ≥50 ns pulse width (≤10 MHz CW) blanks trace of normal intensity. Input R, 5100 ohms.
Persistence
- **Normal:** natural persistence of P31 phosphor (approx 40 µs).
- **Variable:** from <0.2 s to >1 min.

Storage writing speed
- **Write mode:** >20 cm/ms.
- **Max write mode:** >5 cm/µs.

Brightness: >100 foot Lamberts.
Storage time: from Write mode to Store, traces may be stored at reduced intensity for >1 hour. To View mode, traces may be viewed at normal intensity for >1 minute. From Max Write mode to Store, traces may be stored at reduced intensity for >5 minutes. To View mode, traces may be stored at normal intensity for >15 seconds.
Erase: manual, pushbutton erasure takes approx 300 ms.

Horizontal amplifier

External input
- **Bandwidth:** dc-coupled, dc to 5 MHz; ac-coupled, 5 Hz to 5 MHz.
- **Deflection factor:** 1 V/div in X1; 0.2 V/div in X5; 0.1 V/div in X10, accuracy ±5%. Vernier provides continuous adjustment between ranges.
- **Dynamic range:** ±20 V.
- **Maximum input:** 600 V dc (ac-coupled input). Input RC approx 1 megohm shunted by approx 30 pF.

Internal sweep
- **Magnifier:** x5, x10; accuracy, ±5% (with 3% accuracy time base).

Calibrator

Type: approx 1 kHz square wave, 3 µs rise time.
Amplitude: 10 V p-p; accuracy, ±1%.

General

Outputs: four rear panel emitter follower outputs for main and delayed gates, main and delayed sweeps or vertical and horizontal outputs when used with TDR/Sampling plug-ins. Maximum current available, ±3 mA. Will drive impedances ≥1000 ohms without distortion.
Weight (without plug-ins)
- **Model 181A (cabinet):** net, 24 lbs (10,9 kg); shipping, 40 lbs (18,1 kg).
- **Model 181AR (rack):** net, 26 lbs (11,8 kg); shipping, 40 lbs (18,1 kg).

Operating environment: temperature, 0° to +55°C; humidity, to 95% relative humidity to 40°C; altitude, to 15,000 ft; vibration, vibrated in three planes for 15 min each with 0.010 inch excursion, 10 to 55 Hz.
Power: 115 or 230 V ±10%, 48 to 440 Hz, 115 watts at normal line with plug-ins. Max mainframe power, 225 VA.
Dimensions
- **Model 181A (cabinet):** 7⅞" wide x 11⅜" high x 21¼" deep (200 x 289 x 530 mm).
- **Model 181AR (rack):** 16¾" wide x 5¼" high x 21⅜" deep over-all (425 x 132,6 x 543 mm) 19⅜" (493 mm) deep behind rack mounts.

Accessories furnished: 7½ ft power cord, Model 10178A mesh contrast filter; rack mounting hardware and two probe holders (HP P/N 5050-0464) are supplied with rack models.
Price (mainframe less plug-ins)

Model 181A Oscilloscope, Cabinet Style Mainframe	$1950
Model 181AR Oscilloscope Rack Style Mainframe	$2025

Options (order by option number)
- **H49:** Model 181A or 181AR with remote programming capability for Write, Max, Write, Normal, Store, View, and Erase functions. Programming accomplished through contact closure, DTL, or TTL logic sources. Price: Option H49, add $500.

4 and 8 cm/ns WRITING SPEED

Plug-in flexibility, 600 MHz real time

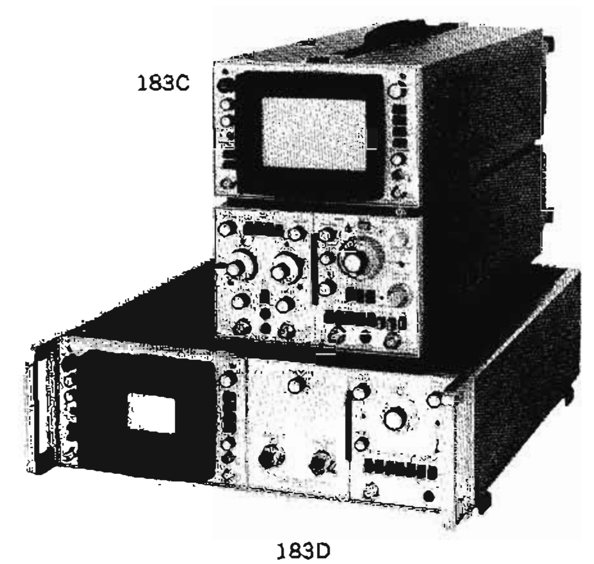
Models 183A, 183B, 183C, 183D

Models 183A/B/C/D mainframes, with their related plug-ins, provide real time frequency response through the VHF region. This high frequency response is accomplished without sacrificing viewing ease, accuracy, operating simplicity, or plug-in versatility in wide band general purpose applications.

The fast writing speed of these main frames allows easy viewing of slow rep rate digital words or other groups of fast-rise pulses in computers and high speed digital systems. In communication system analysis, the wide band response allows undistorted displays of modulation envelopes on rf carriers.

All four mainframes offer full 6 x 10 cm displays at 4 cm/ns writing speed. In addition, the 183C/D offers increased writing speeds of 8 cm/ns in a reduced scan mode. This fast writing speed allows easy photographic recording of high-speed, single-shot transients thru the capabilities of either the 10 mV 250 MHz dual channel plug-in or direct access plug-ins extending to 600 MHz.

To take advantage of this fast writing speed, two time bases are available which provide accurate expanded sweep times to 1 ns/div. Both the standard and delaying time bases provide ultra stable triggering to 500 MHz giving clear clean jitter free displays for all general purpose applications.



Specifications, 183A/B/C/D

Cathode-ray tube and controls

Type: post accelerator, 20 kV accelerating potential; aluminized P31 phosphor (other phosphors available); safety glass faceplate.

Writing speed:* Models 183A/B, 4 cm/ns; Models 183C/D, 4 cm/ns in normal scan; 8 cm/ns in reduced scan.

Graticule

- **Models 183A/B:** 6 x 10 division internal graticule. 1 div = 1 cm. 0.2 division subdivisions on major axes.
- **Models 183C/D:** normal scan, 6 x 10 division internal graticule. 1 div = 1 cm. 0.2 division subdivisions on major axes; reduced scan, 6 x 10 div internal graticule superimposed in center of normal scan graticule. 1 div = 0.5 cm.

Flood gun: illuminates CRT phosphor. Normal or pulsed mode of operation selected with rear panel switch. Scale control adjusts graticule illumination in normal mode and pulse width in pulsed mode which increases photographic writing speed.

Beam finder: returns trace to CRT screen regardless of setting of horizontal or vertical controls.

Intensity modulation: approx +2 V, 50 ns pulse width (≤15 MHz CW) blanks trace of normal intensity. Input R, 4700 ohms. +15 V blanks trace of any intensity.

Calibrator

Pulse timing: selectable, 2 kHz rep rate (0.5 ms period), 50 μs pulse width; 1 MHz rep rate (1 μs period), 100 ns pulse width. Accuracy, ±0.5% +10°C to +40°C; ±1% to +55°C.

Amplitude: selectable, 50 mV or 500 mV, ±1% into a 50 ohm ±0.5% load.

Source R: 50 ohms, nominal.

Pulse shape (measured with 1 GHz bandwidth sampler): rise time (negative slope), 1 ns; overshoot and ringing, ±3% max; flatness, ±0.5% after 5 ns with pulse top and base line perturbations averaged.

External calibrator input: calibrator shaping network shapes an external negative input that exceeds −0.5 V peak. Rep-rate extends to >10 MHz. Input R, approx 10 k ohms. Rear panel input selected with rear panel switch and front panel light indicates when switched to external position.

* With 10,000 ASA film, P31 phosphor, f/1.3 lens, 1:0.5 object-to-image ratio, and pulsed flood gun fogging.

Horizontal amplifier

External input: bandwidth, dc-coupled, dc to 8 MHz; ac-coupled, 2 Hz to 8 MHz; deflection factor, 1 V/div, X1; 100 mV/div, X10; accuracy ±5%, vernier provides continuous adjustment between ranges and extends deflection factor to at least 10 V/div; dynamic range, ±20 V; maximum input, ±350 V (dc + peak ac); input RC, approx 1 megohm shunted by approx 20 pF.

Internal sweep magnifier: X10; accuracy, ±5%.

General

Outputs: two rear panel emitter follower outputs for main or delayed gates (vertical or horizontal outputs when used with sampling plug-ins). Output amplitude is approx ±0.75 V with 1840A time base plug-in. Will drive impedances ≥1000 ohms without distortion.

Weight (without plug-ins): Models 183A/C (cabinet) net, 33 lbs (15,0 kg); shipping, 46 lbs (20,9 kg); Models 183B/D (rack) net, 35 lbs (15,9 kg); shipping, 48 lbs (21,8 kg).

Operating environment (mainframe operates within specifications over the following ranges): temperature, 0°C to 55°C; humidity, to 95% relative humidity to 40°C; altitude, to 15,000 ft; vibration, vibrated in three planes for 15 minutes each with 0.010 inch excursion, 10 to 55 Hz.

Power: 115 or 230 V ±10%, 48 to 440 Hz, approx 115 watts with 1830A and 1840A plug-ins at 115 V and 60 Hz. Maximum mainframe power at normal line, 155 watts.

Dimensions

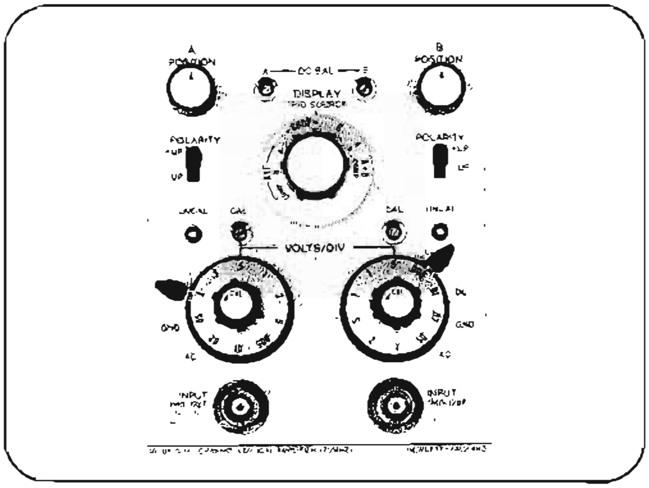
- **Models 183A/C (cabinet):** 7⅞" wide, 11⅜" high, 22¾" deep behind front panel (100 x 289 x 578 mm).
- **Models 183B/D (rack):** 16¾" wide, 5-7/36" high, 24" deep over-all (425.5, 132.6, 543 mm), 22" (558.5 mm) deep behind rack mount tabs.

Accessories supplied: Model 10179A mesh contrast filter, 7½ ft power cord; reduced scan mask for 183C/D (HP Part No. 00183-04111). Rack mounting hardware and two clip-on probe holders (HP Part No. 5050-0464) with 183B and D rack models.

Price (mainframe less plug-ins)

Model 183A Oscilloscope, Cabinet Style Mainframe	$1850
Model 183B Oscilloscope, Rack Style Mainframe	$1925
Model 183C Oscilloscope, Cabinet Style Mainframe	$2500
Model 183D Oscilloscope, Rack Style Mainframe	$2600

75 & 50 MHz, 2 CHANNEL
5 mV/div; High Z or 50 ohms at 75 MHz
Models 1808A, 1801A



Description, 1808A

Model 1808A is an ideal vertical amplifier for design or trouble-shooting logic circuits using ECL components. This plug-in provides low drift and flexible triggering for accurate CW and timing measurements. Other convenience features are: 5 mV/div to 10 V/div; dc to 75 MHz bandwidth on all ranges; selectable display polarity on each channel; and selectable high Z or 50 ohm inputs.

General purpose probing is provided by a one megohm input with a very low 12 pF shunt capacitance to reduce phase shift and signal loss in CW measurements. A switchable, high quality, 50 ohm input is also provided, which allows matching to a 50 ohm source with minimum reflections due to the low 1.2:1 VSWR. This 50 ohm input provides accurate rise time measurements with virtually no reflections to degrade the input signal or introduce phase shift. The 50 ohm input also allows active and passive probes with very low input capacitance to be used which further reduces signal degradation.

Specifications, 1808A

Modes of operation: channel A; channel B; channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at approx 400 kHz rate (CHOP), with blanking during switching; and channel A plus channel B (algebraic addition).

Each channel (2)

Bandwidth: (3 dB down from 8 div reference signal from a terminated 50 ohm source): dc-coupled, dc to 75 MHz; ac-coupled, approx 8 Hz to 75 MHz.

Rise time: <4.7 ns (measured from 10% to 90% points of 6 div input step from a terminated 50 ohm source).

Deflection factor

Ranges: 5 mV/div to 5 V/div (10 calibrated positions) in 1, 2, 5 sequence. ±2% attenuator accuracy. Vernier provides continuous adjustment between deflection factor settings and extends maximum deflection factor to at least 12.5 V/div.

Polarity: + up or − up, selectable.

Signal delay: input signals are delayed sufficiently to view leading edge of input pulse without advanced trigger.

Input coupling: selectable, ac and dc (1 megohm), 50 ohms (dc), or ground. Ground position disconnects input connector and grounds amplifier input.

Input (selectable)

AC and DC: 1 megohm ±1% shunted by approx 12 pF.

50 ohm: 50 ohms ±1%, VSWR, <1.2:1 at 75 MHz on all ranges.

Maximum Input

AC and DC: ±300 V (dc + peak ac) at 1 kHz or less; ±150 V (dc + peak ac) on 5 mV/div range at 1 kHz or less.

50 ohm: 10 V rms (dc-coupled input).

Drift: <100 μV/°C.

A + B operation

Amplifier: bandwidth and deflection factors are unchanged; either channel may be inverted for ±A + B operation.

Differential Input (A-B) common mode: for frequencies from dc to 2 MHz, CMRR is at least 40 dB on 5 mV/div and at least 20 dB on other ranges for common mode signals of 24 div or less.

Triggering

Source: A, B, or composite (A + B) modes, on the signal displayed; chop mode, on A or B signal; alternate mode, on A, B, or successively (comp) from the displayed signal on each channel.

Frequency: dc to 75 MHz on signals causing 0.5 div p-p or more vertical deflection in all display modes (1820A, 1821A require 1 div p-p) except dc to 100 kHz in chop mode.

General

Operating environment: same as Model 180C/D mainframe.

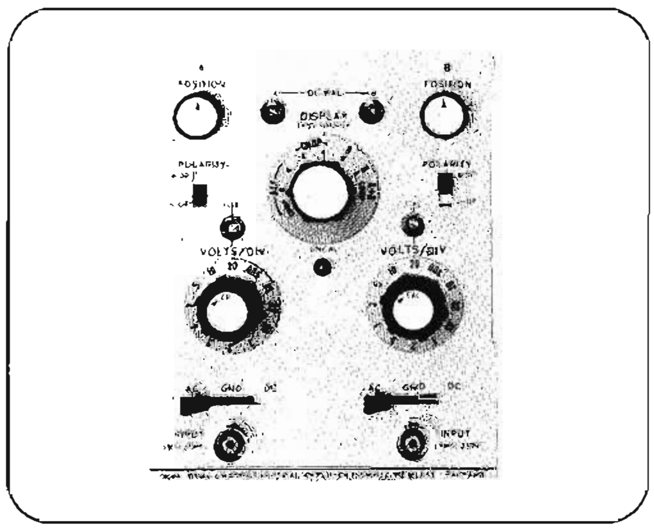
Weight: net, 5 lbs (2,3 kg); shipping, 9 lbs (4,1 kg).

Price: Model 1808A Dual Channel Vertical Amplifier, $880.

Accessories furnished: two 10:1 voltage divider probes.

Options

003: Model 1808A without probes, less $80.



Description, 1801A

Model 1801A is a dual channel vertical amplifier plug-in for 180 system mainframes. Operating characteristics are: 5 mV/div to 10 V/div deflection factors; dc to 50 MHz bandwidth constant on all ranges; selectable display polarity; and selectable input coupling. The two channels can be operated singly, algebraically added, or in dual trace modes with alternate or chopped switching and selectable trigger source.

For added measurement versatility, Option 001 provides a X5 multiplier for 1 mV/div deflection factors. Option 001 also provides a Channel B output, which can be cascaded into Channel A for 500 μV/div deflection factor.

Specifications, 1801A

Modes of operation: channel A; channel B; channels A and B displayed alternately on successive sweeps (ALT); channels A

35 MHz, LOW COST, 2 CHANNEL
10 mV/div, Easy-to-use
Model 1807A

and B displayed by switching between channels at approx 400 kHz rate (CHOP), with blanking during switching; channel A plus channel B (algebraic addition).

Each channel (2)

Bandwidth (measured with or without a Model 10004B probe, 3 dB down from 8 div reference signal from a terminated 50 ohm source): dc-coupled, dc to 50 MHz; ac-coupled, approx 8 Hz to 50 MHz. Lower limit is approx 0.8 Hz with 10004B probe.

Rise time: <7 ns (measured with or without 10004B probe 10% to 90% of 8 div input step from a terminated 50 ohm source).

Deflection factor: 5 mV/div to 20 V/div (12 positions) in 1, 2, 5 sequence. ±3% attenuator accuracy. Vernier provides continuous adjustment between deflection factor settings and extends maximum deflection factor to at least 50 V/div.

Polarity: + up or − up, selectable.

Signal delay: input signals are delayed sufficiently to view leading edge of input pulse without advanced external trigger.

Input coupling: selectable, ac, dc, or ground. Ground position disconnects signal input and grounds amplifier input.

Input RC: 1 megohm ±2% shunted by approx 25 pF.

Maximum input

DC-coupled: ±350 V (dc + peak ac) at 10 kHz or less; ±150 V (dc + peak ac) on 5 mV/div range at 10 kHz or less.

AC-coupled: ±600 V dc.

A + B operation

Amplifier: bandwidth and deflection factors are unchanged, either channel may be inverted for ±A ±B operation.

Differential input (A-B) common mode: CMRR is at least 40 dB at 5 mV/div and at least 20 dB on other ranges for frequencies between dc and 1 MHz and for common mode signals of 24 div or less.

Triggering

Source: A, B, or composite (A + B) modes, on the signal displayed; chop mode, on A or B signal; alternate mode, on A, B or successively (comp) from the displayed signal on each channel.

Frequency: dc to 50 MHz on signals causing 0.5 div or more vertical deflection in all display modes except dc to 100 kHz in chop mode.

General

Weight: net, 4 lbs (1,8 kg); shipping, 7 lbs (3,2 kg).

Environment: same as Model 180C/D mainframes.

Accessories furnished: two 10004B, 10:1 divider probes, approx 3½ ft.

Price: Model 1801A Dual Channel Vertical Amplifier, $680; Model 1801A Option 003 Dual Channel Vertical Amplifier, $600.

Options (order by option number)

001: provides x5 magnifier and channel B vertical output. Contact your Hewlett-Packard field engineer for more information about this option.

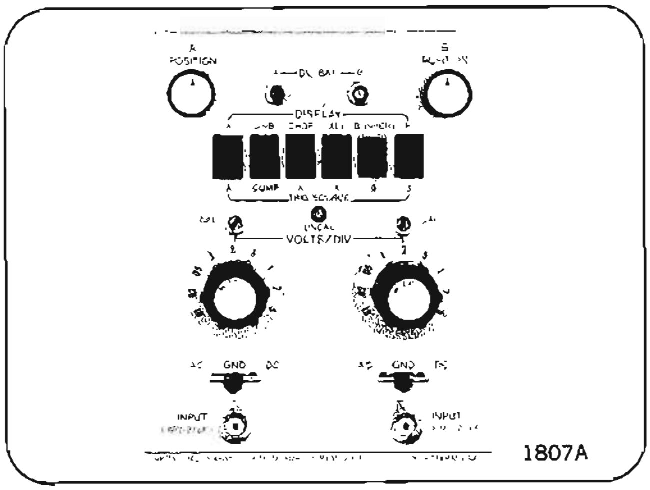
003: Model 1801A without probes, less $80.

090: 6 ft 10006B probes substituted for 10004B, 10:1 atten, no charge.

091: 10 ft 10005B probes substituted for 10004B, 10:1 atten, no charge.

Description, 1807A

Model 1807A is an economical, dual channel plug-in for applications involving logic timing measurements in circuits using MOS and TTL elements. A selection of standard, delay generators, or expanded sweep time bases, allow timing measurements to 5 ns/div in 180 mainframes or to 1 ns/div in 183 mainframes. The 181 or 184 variable persistence/storage mainframes provide bright, clear displays of low rep rate logic pulses when they are too slow for standard CRT displays.



Specifications, 1807A

Modes of operation: channel A; channel B; channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at approx 100 kHz rate (CHOP), with blanking during switching; and channel A plus channel B (algebraic addition).

Each channel (2)

Bandwidth: (measured with or without 10004B probe, 3 dB down from 8 div reference signal from a terminated 50 ohm source): dc-coupled, dc to 35 MHz; ac-coupled, approx 8 Hz to 35 MHz. Lower limit is approx 0.8 Hz with 10004B probe.

Rise time: <10 ns (measured with or without 10004B probe, 10% to 90% of 8 div input from a terminated 50 ohm source).

Deflection factor: 10 mV/div to 5 V/div (9 positions) in 1, 2, 5 sequence. ±3% attenuator accuracy. Vernier provides continuous adjustment between deflection factor settings and extends maximum deflection factor to 12.5 V/div.

Polarity: + UP or − UP, selectable on channel B.

Signal delay: input signals are delayed sufficiently to view leading edge of input pulse without advanced trigger.

Input RC: 1 megohm ±2% shunted by approx 27 pF.

Input coupling: selectable, ac, dc, or ground. Ground position disconnects input connector and grounds amplifier input.

Maximum input

DC-coupled: ±350 V (dc + peak ac) at 10 kHz or less; ±150 V (dc + peak ac) on 10 mV/div at 10 kHz or less.

AC-coupled: ±600 V dc.

A + B operation

Amplifier: bandwidth and deflection factors are unchanged; channel B may be inverted for +A±B operation.

Differential input (A-B) common mode: for frequencies from dc to 1 MHz, CMRR is at least 40 dB on 10 mV/div and at least 20 dB on other ranges for common mode signals of 24 div or less.

Triggering

Source: on channel A for channel A, chop and alternate modes, on channel B for channel B mode, on signal displayed for A + B mode.

Frequency: dc to 35 MHz on signals causing 0.5 div p-p or more vertical deflection in all display modes except dc to 100 kHz in chop mode.

General

Environment: same as 180C/D mainframe.

Weight: net, 4 lbs (1,8 kg); shipping, 8 lbs (3,6 kg).

Price: Model 1807A Dual Channel Vertical Amplifier, $450.

DIFFERENTIAL/DC OFFSET
Calibrated V_0 to 600 V
Model 1803A

Description, 1803A

Model 1803A is a differential/dc offset amplifier plug-in for 180 system mainframes. Operating characteristics are: deflection factors of 1 mV/div to 2 V/div from dc to 30 MHz and from 5 mV/div to 20 V/div to 40 MHz; CMRR of 86 dB (20,000:1) on the 1 mV/div range with a 10 volt common mode signal; and calibrated offset voltage that provides differential comparison of pulse amplitude measurements with 0.5% accuracy.

Specifications, 1803A

Vertical deflection

Bandwidth: (measured with or without 10004B probe, 3 dB down from an 8 div reference signal from a terminated 50 ohm source.)

DC-coupled: dc to 40 MHz from 0.005 V/div to 20 V/div; dc to 30 MHz on 0.001 V/div and 0.002 V/div or when using V_0 range of 0 to 6V or two most sensitive volts/div settings for other V_0 ranges.

AC-coupled: lower bandwidth limit is approximately 2 Hz, upper bandwidth is the same as dc-coupled. Lower bandwidth is approx 0.2 Hz with 10004B probe.

Risetime: <10 ns for deflection factors of 0.005 V/div to 20 V/div; <12 ns on 0.001 V/div and 0.002 on V_0 range of 0 to 6 V and on two most sensitive volts/div setting for other V_0 ranges. (Measured with or without 10004B probe, 10% to 90% points of input step from a terminated 50 ohm source.)

Deflection factor

Ranges: from 0.001 V/div to 20 V/div (14 calibrated positions) in 1, 2, 5 sequence. ±3% attenuator accuracy.

Vernier: provides continuous adjustment between deflection factor settings; extends maximum deflection factor to at least 50 V/div. Uncalibrated light indicates when vernier is not in CAL position.

Input coupling: ac, dc, ground, or V_0 for both + and − inputs. Ground disconnects signal input and grounds amplifier input for reference.

Maximum input

V_0 Range	Deflection Factor	Maximum Input (dc + peak ac)
0 to 6 V	0.001 V/div to 0.02 V/div	± 15 V
0 to 6 V	0.05 V/div to 0.2 V/div	±150 V
0 to 6 V	0.5 V/div to 20 V/div	±600 V
0 to 60 V	0.01 V/div to 0.2 V/div	±150 V
0 to 60 V	0.5 V/div to 20 V/div	±600 V
0 to 600 V	0.1 V/div to 20 V/div	±600 V

Overload recovery

6 V overload: within ±10 mV of final signal value in ≤0.3 μs within ±5 mV in ≤1 μs, and within 1 mV in ≤1 ms.

60 V overload: within ±100 mV of final signal value in ≤0.3 μs, within ±50 mV in ≤1 μs, and within ±10 mV in ≤1 ms.

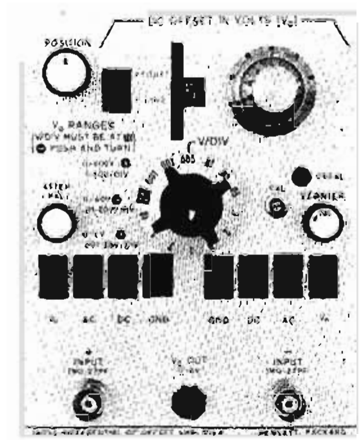
600 V overload: within ±1 V of final signal value in ≤0.3 μs, within ±0.5 V in ≤1 μs, and within ±100 mV in ≤1 ms.

Common mode rejection ratio: measured at 0.001 V/div. (CMRR decreases with increasing deflection factor.)

Frequency Range	CMRR	Common Mode Input Sinewave (Max p-p)
DC to <100 kHz	≥20,000:1 (≥86 dB)	10 V
100 kHz to <1 MHz	≥10,000:1 (≥80 dB)	10 V
1 MHz to <10 MHz	$\geq \frac{5{,}000:1}{\text{Freq. in MHz}}$	$\frac{10\text{ V}}{\text{Freq. in MHz}}$
20 MHz	≥50:1 (≥34 dB)	1 V
60 Hz	≥2,000:1 (≥66 dB)*	10 V

V_0 output: calibrated dc offset voltage available at front panel connector, continuously variable from 0 to ±0.006 V, 0 to ±0.06 V, 0 to ±0.6 V, or 0 to ±6 V. Accuracy of the ±6 V range is ±0.15% of reading ±8 mV when driving a resistance of 10 megohms or higher.

* AC coupled (all others dc-coupled).



1803A

DC offset

V_0 Range	Deflection Factor	Comparison Accuracy
0 to ±6 V	0.001 V/div to 0.02 V/div	±(0.15% + 8 mV)
	0.05 V/div to 0.2 V/div	±(0.75% + 8 mV)
	0.5 V/div to 2 V/div	±1%
	5 V/div to 20 V/div	±3%
0 to ±60 V	0.01 V/div to 0.2 V/div	±(0.4% + 80 mV)
	0.5 V/div to 2 V/div	±(0.75% + 80 mV)
	5 V/div to 20 V/div	±3%
0 to ±600 V	0.1 V/div to 2 V/div	±(0.65% + 0.8 V)
	5 V/div to 20 V/div	±3%

Triggering: dc to 40 MHz on signals causing 0.5 div or more vertical deflection.

General

Weight: net, 5 lbs (2,3 kg); shipping, 8 lbs (3,6 kg).

Environment: same as Model 180C/D mainframes.

Price: Model 1803A Differential DC Offset Amplifier, $1025.

Description, 1804A

Model 1804A is a four channel vertical amplifier plug-in for 180 system mainframes. Operating characteristics are: 20 mV/div to 10 V/div deflection factors; dc to 50 MHz bandwidth; and selectable input coupling. The four channels may be operated singly or in any combination of traces in alternate or chopped modes with selectable trigger source.

Specifications, 1804A

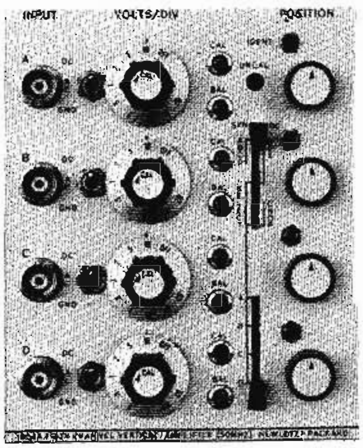
Modes of operation: channel A, B, C, or D or any combination displayed alternately on successive sweeps (ALT); channels A, B, C, or D or any combination displayed by switching between channels at approx 1 MHz rate (CHOP), with blanking during switching.

Each channel (4)

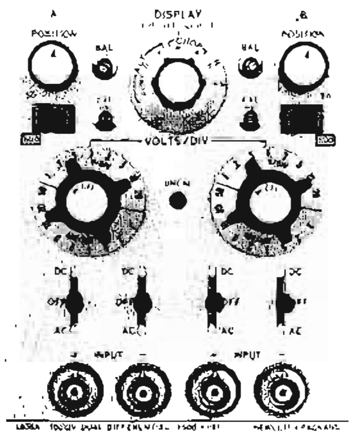
Bandwidth: (measured with or without 10004B probe 3 dB down from 8 div reference signal from a terminated 50 ohm source.) DC-coupled, dc to 50 MHz; ac-coupled, 10 Hz to 50 MHz. Lower limit is approx 1 Hz with 10004B probe.

Risetime: <7 ns. (Measured with or without 10004B probe; 10% to 90% of 8 div input step from a terminated 50 ohm source.)

4 CHANNEL; HIGH GAIN
10 mV/div to 50 MHz; 100 μV/div to 500 kHz
Models 1804A, 1806A



1804A



1806A

Deflection factor

Ranges: from 0.02 V/div to 10 V/div (9 calibrated positions) in 1, 2, 5 sequence. ±3% attenuator accuracy.

Vernier: provides continuous adjustment between all deflection factor ranges; extends maximum deflection factor to at least 25 V/div. Uncalibrated light indicates when vernier is not in CAL position.

Signal delay: input signals are delayed sufficiently to view leading edge of input pulse without advanced ext trigger.

Input coupling: ac, dc, or ground. Ground disconnects input signal and grounds amplifier input for reference.

Input RC: 1 megohm ±2% shunted by approx 25 pF.

Maximum input: dc-coupled, ±350 V (dc + peak ac) at 10 kHz or less; ±150 V (dc + peak ac) on 20 mV/div at 10 kHz or less; ac-coupled, ±400 V dc.

Trace identification: pushbutton control displaces respective trace approx 0.5 div.

Triggering

Source: selectable on signal from any channel in either chop or alternate mode, or successively from the displayed signal on each channel in alternate mode.

Frequency: dc to 50 MHz on signals causing 0.5 div or more vertical deflection in all display modes except chop; dc to 200 kHz in chop mode.

General

Accessory supplied: Model 10412A extender card for ring counter board.

Weight: net, 5 lbs (2,3 kg); shipping, 8 lbs (3,6 kg).

Environment: same as Model 180C/D mainframes.

Price: Model 1804A Four Channel Vertical Amplifier, $1050.

Description, 1806A

Model 1806A is a dual channel, differential input amplifier for low level measurements in 180 system mainframes. Operating characteristics are: dc to 500 kHz bandwidth, 100 μV/div to 20 V/div deflection factors, 100 dB CMRR from dc to 10 kHz with a ±10 V common mode signal on the 100 μV/div range, and less than 20 μV of noise, measured tangentially at full bandwidth.

Specifications, 1806A

Modes of operation: channel A alone; channel B alone; channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at approx 100 kHz rate (CHOP) with blanking during switching.

Each channel (2)

Bandwidth: (measured with or without 10012B probe 3 dB down from 8 div reference from a terminated 50 ohm source) dc-coupled, dc to 500 kHz; ac-coupled, approx 2 Hz to 500 kHz lower limit is approx 0.2 Hz with 10012B probe. Bandwidth limit switch reduces upper bandwidth to approx 50 kHz.

Deflection factor

Ranges: from 100 μV/div to 20 V/div (17 positions) in 1, 2, 5 sequence. ±3% attenuator accuracy.

Vernier: provides continuous adjustment between deflection factor settings and extends maximum deflection factor to at least 50 V/div.

Input: differential or single-ended on all ranges, selectable.

Input coupling: selectable AC, DC, or OFF for both + and − inputs. Off position disconnects signal input and grounds amplifier input for reference.

Input RC: 1 megohm shunted by approx 45 pF.

Maximum input: ±400 V (dc + peak ac).

Input isolation: $\geq$80 dB between channels at 500 kHz with shielded input connectors.

Noise: 20 μV, measured tangentially at full bandwidth.

Common mode

Frequency: dc to 10 kHz on all ranges.

Rejection ratio: $\geq$100 dB (100,000 to 1) with dc-coupled input on 100 μV/div range, decreasing 20 dB per decade of deflection factor to $\geq$40 dB on the 200 mV/div range; CMRR is $\geq$30 dB on the 500 mV/div to 20 V/div ranges.

Maximum signal: ±10 V (dc + peak ac) on 100 μV/div to 200 mV/div ranges; ±400 V (dc + peak ac) on all other ranges.

Triggering

Source: for channel A and B on the signal displayed; chop selectable for channel A or B; Alt selectable from channel A,B, or Comp (channel A and B switched).

Frequency: dc to >500 kHz on signals causing 0.5 div or more vertical deflection in all display modes except Chop. DC to 100 kHz in Chop.

General

Weight: net, 3½ lbs (1,6 kg); shipping, 6½ lbs (3,0 kg).

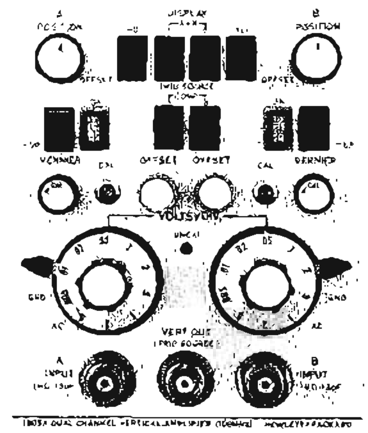
Environment: same as Model 180C/D mainframe.

Price: Model 1806A Dual Differential Vertical Amplifier, $675.

Accessories furnished: two BNC to dual banana plug binding post adapters. HP Part No. 1250-1264.

Recommended probes (not supplied with Model 1806A): Models 10001A/B, 10002A/B, 10003A, 10007B; 10008B, and 10012B. Refer to oscilloscope accessories for more information.

100 MHz, DUAL CHANNEL
5 mV/div, High Z or 50 ohm inputs
Model 1805A



1805A

Description, 1805A

Model 1805A, 100 MHz vertical amplifier provides accurate measurements for both digital and analog design and troubleshooting. A selectable high impedance with low input capacitance or 50 ohm input provides accurate pulse and CW measurements. Other features that provide accurate, convenient measurements are: flexible triggering, 5 mV/div to 10 V/div deflection factors from dc to 100 MHz on all ranges, selectable display polarity on each channel, and up to ±200 divisions of offset.

A new planar attenuator of thick film design now makes it possible to have both a low capacitance, high impedance input for probing and a precision 50 ohm input for transmission line measurements. In the high Z position (ac/dc) a 1 megohm input with only 13 pF shunt capacitance is established. This extremely low capacitance provides minimal loading in all probing applications, which can be reduced even further by using 10:1 divider probes. For precision 50 ohm measurements, a terminated 50 ohm input may be selected with a front panel switch. The internal termination is maintained at a high degree of quality by compensating for the normal scope input capacitance, which cannot be accomplished with an external termination. The internal termination also makes possible the high 10 volt maximum input capability.

Active probes are also available to reduce circuit loading while retaining the precision 50 ohm input measurement capability. Probe capacitance with the 1120A and its divider tips is less than 1 pF and with the 10020A passive resistive divider is less than 0.7 pF.

The dc offset capability of ±200 div makes measurements easy with low level non-symetrical logic. This dc offset allows dc offset on logic pulses to be restored while maintaining the low frequency pulse characteristics necessary in most logic measurements.

Timing measurements are fast and easy with the selection of trigger source from channel A or B or composite of A and B. This allows you to trigger on either channel while viewing the time relationship with the other channel or by selecting composite triggering each channel is individually triggered.

Specifications, 1805A

Modes of operation: channel A; channel B; channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at approx 600 kHz rate (CHOP), with blanking during switching channel A plus channel B (algebraic addition).

Each channel (2)

Bandwidth: (measured with or without 10014A probe, 3 dB down from 8 div reference signal from a terminated 50 ohm source). DC-coupled; dc to 100 MHz; ac-coupled; approx 10 Hz to 100 MHz (lower limit is approx 1 Hz with 10014A probe).

Rise time: <3.5 ns (measured with or without 10014A probe from 10% to 90% points of 6 div input step from a terminated 50 ohm source).

Deflection factor

Ranges: 5 mV/div to 5 V/div (10 calibrated positions) in 1, 2, 5 sequence. ±2% attenuator accuracy.

Vernier: provides continuous adjustment between deflection factor settings and extends maximum deflection factor to at least 12.5 V/div. Uncalibrated light indicates when vernier is not in CAL position.

Dynamic range: 6 div at 100 MHz increasing to 16 div at ≤15 MHz.

Positioning range: 16 div.

Offset: ±200 div; maximum offset on 2 volt range and above is limited by 300 volt maximum input voltage specification.

Polarity: + up or − up, selectable.

Signal delay: input signals are delayed sufficiently to view leading edge of input pulse without advanced trigger.

Input coupling: ac, dc, 50 ohms (dc), or ground. Ground position disconnects input connector and grounds amplifier input.

Input RC

AC and dc: 1 megohm ±1% shunted by approx 12 pF.

50 ohm: 50 ohms ±1%. VSWR, <1.2:1 at 100 MHz on all ranges.

Maximum input

AC and dc: ±300 V (dc + peak ac) at 1 kHz or less; ±150 V (dc + peak ac) on 5 mV/div range at 1 kHz or less.

50 ohm: 10 V rms (dc-coupled input).

A + B operation

Amplifier: bandwidth and deflection factors are unchanged; either channel may be inverted for ± A ±B operation.

Differential input (A-B) common mode: for frequencies from dc to 1 MHz, CMRR is >40 dB for common mode signals up to 16 div. CMRR is at least 20 dB at 50 MHz for common mode signals of 6 div or less.

Triggering

Source: selectable from channel A, channel B, or composite (A + B) signal in any display mode.

Frequency: dc to 50 MHz on signals causing 0.5 div p-p increasing to 1 div (2 div for 1822A) at 100 MHz, or more vertical deflection in all display modes except dc to 100 kHz in chop mode.

Vertical signal output

Source: channel A, channel B, or channels A + B selected by Trigger Source.

Amplitude: approx 50 mV/div of display into 50 ohms with useable amplitudes up to 500 mV p-p.

Bandwidth: dc to approx 50 MHz into 50 ohms.

General

Weight: net, 5 lbs (2,3 kg); shipping, 8 lbs (3,6 kg).

Operating environment: same as Models 180C/D.

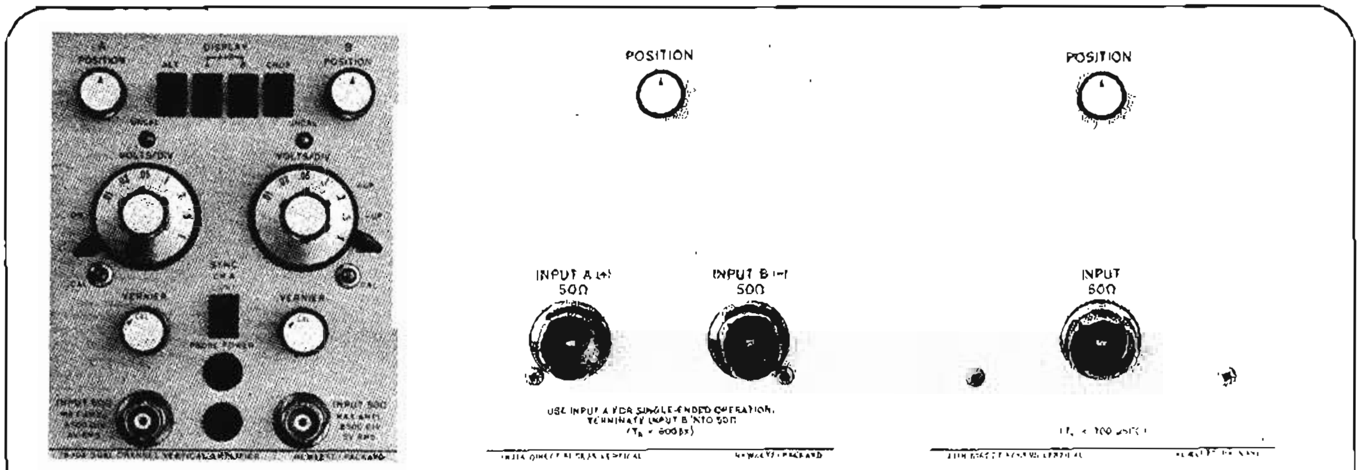
Accessories furnished: two 10014A 10:1 voltage divider probes.

Price: Model 1805A Dual Channel Vertical Amplifier $1400

Model 1805A Option 003, less probes $1300

250 to 600 MHz VERTICALS
10 mV/div to 250 MHz, large signal to >600 MHz
Models 1830A, 1831A, 1831B

OSCILLOSCOPES



1830A 1831A 1831B

Specifications, 1830A

Modes of operation: channel A alone, channel B alone, channels A and B displayed alternately on successive sweeps (ALT), channels A and B displayed by switching (time shared) between channels, chop frequency of approx 250 kHz, channel A plus channel B, and by inverting channel B, channel A minus channel B.

Each channel (2)

Bandwidth: dc to 250 MHz, 3 dB down from 6 div reference signal at 10 MHz from a 50 ohm source.

Risetime: ≤1.5 ns. 10% to 90% with 6 div input step with a risetime of ≤200 ps from a 50 ohm source.

Pulse response: overshoot, ringing, flatness (combined), <±4%; preshoot, <0.5%.

Deflection factor

Ranges: from 0.01 V/div to 1 V/div (7 positions) in 1, 2, 5 sequence. ±3% attenuator accuracy (front panel Cal adjust).

Vernier: continuously variable between all ranges, extends maximum deflection factor to approx 2.5 V/div. Vernier UNCAL (uncalibrated) light indicates when vernier is not in the calibrated position.

Polarity: + up or − up selectable on channel B.

Signal delay: >55 ns, which allows viewing the leading edge of a pulse without external delay or advanced trigger.

Drift: short term drift/min. and long term drift/hr, ≤0.05 div after ½ hr from turn-on and at constant ambient temperature.

Input R: 50 ohms.

Maximum input: 5 V rms or ±500 div peak, whichever is less.

VSWR: ≤1.30 on 10 mV/div and ≤1.20 from 20 mV/div to 1.0 V/div at 250 MHz.

Reflection coefficient: ≤10% on 10 mV/div and ≤5% from 20 mV/div to 1.0 V/div. Measured with 1 ns risetime TDR.

A + B operation (A-B with channel B inverted)

Bandwidth: dc to 150 MHz, 3 dB down from 6 div reference signal from a terminated 50-ohm source.

Risetime: ≤2.4 ns, 10% to 90% with 6 div input step from a terminated 50-ohm source.

Triggering

Source: channel A or composite (on displayed signal) in all display modes.

Frequency: dc to >250 MHz on signals causing 1 div or more vertical deflection in all modes (with Model 1840A and 1841A Time Bases).

General

Probe power: provides power for operating two Hewlett-Packard probes.

Weight: net, 5 lbs (2,3 kg); shipping, 8 lbs (3,6 kg).

Operating environment: same as 183 mainframe.

Price: Model 1830A, 250 MHz Vertical Amplifier $950

Specifications, 1831A and 1831B

Note

These plug-ins require Option 035 to the 183 mainframes and the 1840A time base.

Vertical

Bandwidth: <20 kHz to >600 MHz (1831A), >500 MHz (1831B).

Rise time: <600 ps (1831A), <700 ps (1831B).

Pulse response: <5% overshoot; <±5% perturbations with 350 ps rise time step input from a 50 ohm source; <6% tilt for a 1 μs wide pulse at 25°C and <10% tilt from 0°C to 55°C.

Deflection factor: 5.75 V/div, ±10%.

Input characteristics

Input R: 50 ohms, single-ended or differential (1831A); single-ended (1831B).

Maximum dc input: ±100 V dc.

Maximum ac input: 2.0 watts, 4 div p-p CW.

VSWR: <1.3:1 to 750 MHz.

Input reflections: <±10%, measured with 150 ps TDR.

Signal delay (1831B): approx 60 ns which allows viewing leading edge of a pulse without external delay.

Internal triggering (1831B): stable to 500 MHz with signals producing ½ div or more vertical deflection.

General

Weight: 1831A net, 2 lbs (0,91 kg); shipping, 5 lbs (2,27 kg). 1831B net, 4 lbs (1,81 kg); shipping, 7 lbs (3,18 kg).

Operating environment: same as Model 183 mainframe.

Accessories furnished: one 50 ohm load, HP Part No. 0950-0090 (1831A only). Two mainframe termination resistors, HP Part No. 01831-61501.

Price

Model 1831A Direct Access Plug-in	$375
Model 1831B Direct Access Plug-in	$425

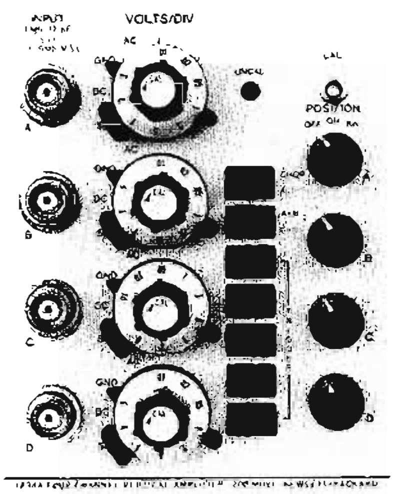
Options

001: 100 ohm input for 1831A. Specifications for model 1831A Option 001 are the same as Model 1831A except as follows:
Bandwidth: <10 kHz to >600 MHz.
Deflection factor: 5 V/div, ±10%.
Input R: 100 ohms, single-ended or differential.
Tilt: <3% for a 1 μs wide pulse at 25°C; <5% (0° to 55°C).
Maximum ac input: 2 watts, i.e. 8 div p-p CW.
Price: Model 1831A Option 001 add $50

200 MHz, 4 CHANNELS

10mV/div, High Z or 50 ohm, inputs

Model 1834A



Description, 1834A

Model 1834A, 200 MHz four channel vertical amplifier provides accurate measurements for both digital and analog design and troubleshooting. With the 1834A, you can make four channel measurements in systems designed with ECL logic. This coupled with the 1 ns/div sweep speeds available with the 1840A or 1841A time bases allows accurate timing measurements in complex logic circuits.

A thick film, planar attenuator allows both a high impedance input, with very low shunt capacitance, for general purpose probing and a precision 50 ohm input for transmission line measurements. In the high impedance position (ac/dc) a 1 megohm input with only 12 pF shunt capacitance is established. This extremely low capacitance provides minimal loading in probing applications, which can be further reduced by using 10:1 divider probes. For precision 50 ohm measurements, a precision internal 50 ohm input termination may be selected with a front panel switch. The internal termination is maintained at a high degree of quality by compensating for the normal scope input capacitance, which is not possible with external terminations. The internal termination also makes possible the high 10 volt maximum input capability.

Active probes are available to reduce circuit loading while retaining the precision 50 ohm input measurement capability.

Timing measurements are fast and easy with the selection of trigger source from channel A, B, C, or D or composite in all displays modes. This allows you to trigger on any channel while retaining the time relationship with the other three channels. By selecting composite triggering each channel is individually triggered.

Specifications

Modes of operation: channel A, B, C, or D or any combination displayed alternately on successive sweeps (ALT); channels A, B, C, or D or any combination displayed by switching between channels at approx 750 kHz rate (CHOP) with blanking during switching; channels ±A ±B displayed in ALT or CHOP with ±C ±D, chop frequency is approx 1.5 MHz.

Each channel (4)

Bandwidth: (measured with or without 10014A probe, 3 dB down from a 6 div reference signal from a terminated 50 ohm source). DC-coupled, dc to 200 MHz; ac-coupled, approx 10 Hz to 200 MHz. Lower limit is approx 1 Hz with 10014A probe when ac-coupled.

Rise time: <1.8 ns (measured with or without 10014A probe; 10% to 90% of 6 div input step from a terminated 50 ohm source).

Deflection factor

Ranges: from 0.01 V/div to 5 V/div (9 calibrated positions) in 1, 2, 5 sequence. ±2% attenuator accuracy.

Vernier: provides continuous adjustment between all deflection factor ranges; extends maximum deflection factor to at least 12.5 V/div.

Signal delay: input signals are delayed sufficiently to view leading edge of input pulse without advanced external trigger.

Input coupling: ac, dc, 50 ohms (dc), or ground. Ground position disconnects input connector and grounds amplifier input.

Input (selectable)

AC and dc: 1 megohm ±1% shunted by approx 12 pF.

50 ohm: 50 ohms ±1%. VSWR, 1.2:1 at 200 MHz on all ranges.

Maximum Input

AC and dc: ±300 V (dc + peak ac) at 1 kHz or less; ±150 V (dc + peak ac) on 10 mV/div range at 1 kHz or less.

50 ohm: 10 V rms (dc-coupled input).

A + B operation

Amplifier: bandwidth and deflection factors are unchanged; any channel may be inverted for ±A ±B or ±C ±D operation.

Differential input (A-B or C-D) common mode: CMRR is at least 20 dB from dc to 80 MHz on 10 mV/div to 5 V/div ranges.

Triggering

Source: selectable from channel A, B, C, D, or composite (on displayed signal) in all display modes.

Frequency: dc to 50 MHz on signals causing 0.5 div or more vertical deflection increasing to 1 div at 200 MHz in all display modes.

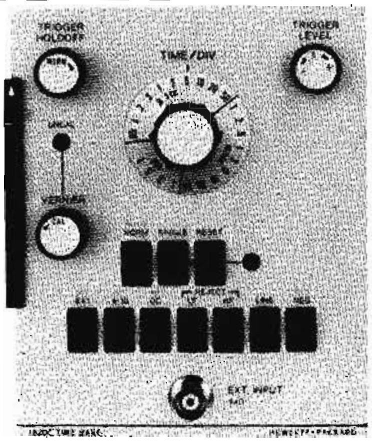
General

Weight: net, 7 lb (3,2 kg); shipping, 10 lb (4,5 kg).

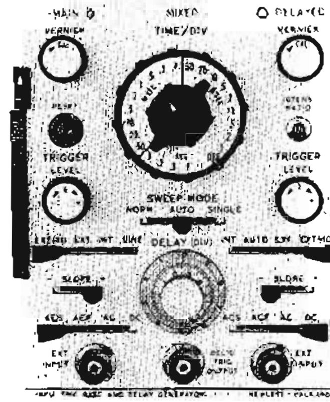
Environment: same as 183 mainframe.

Price: Model 1834A 200 MHz 4 channel amplifier $1900

LOW COST TIME BASES
Single & delayed; 150 & 50 MHz triggering
Models 1820C, 1821A



1820C



1821A

Specifications, 1820C

Time base

Sweep

Ranges: 50 ns/div to 1 s/div (23 positions) in 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between ranges, extends slowest sweep to at least 2.5 s/div. Uncalibrated light indicates when vernier is not in CAL position.

Magnifier: (on mainframe) expands fastest sweep to 5 ns/div.

Sweep mode

Normal: triggered by an int, ext or power line signal.

Automatic: bright baseline displayed in absence of trigger signal. Triggering is same as Normal except low frequency limit is 40 Hz.

Single: in Normal, sweep occurs once with same triggering as Normal; reset pushbutton arms sweep and lights indicator; in Auto, sweep occurs once each time reset pushbutton is pressed.

Triggering

Internal: refer to vertical amplifier plug-in specifications.

External: dc to 50 MHz on signals 50 mV p-p or more increasing to 100 mV at 100 MHz and 150 mV at 150 MHz.

Line: power line frequency signal.

Level

Internal: at any point on the vertical waveform displayed.

External: continuously variable from +2 V to −2 V on either slope of trigger signal, from +20 V to −20 V ÷10 setting.

Slope: pushbutton selects + or − slope of trigger signal.

Coupling: front panel selection of AC, DC, HF Reject, or LF Reject. AC attenuates signals below approx 20 Hz, LF Reject attenuates signals below approx 15 kHz, HF Reject attenuates signals above approx 15 kHz.

Trigger holdoff: time between sweeps continuously variable, exceeding on full sweep on all ranges.

General

Operating environment: same as 180C/D mainframes.

Weight: net, 3 lbs (1,4 kg); shipping, 7 lbs (3,2 kg).

Price: Model 1820C Time Base, $400.

Specifications, 1821A Delayed Time Base

Main time base

Sweep

Ranges: 0.1 μs/div to 1 s/div (22 positions) in 1, 2, 5 sequence. ±3% accuracy with vernier in CAL position.

Vernier: continuously variable between all ranges; extends slowest sweep to at least 2.5 s/div.

Magnifier: (on mainframe) expands fastest sweep to 10 ns/div.

Sweep mode

Normal: triggered by an int, ext, or power line signal.

Automatic: bright baseline displayed in absence of input signal. Triggering same as normal except low frequency limit is 40 Hz for internal or external modes.

Single: sweep occurs once with same triggering as normal; reset pushbutton with armed indicator light.

Triggering

Internal: refer to vertical amplifier plug-in specifications.

External: from dc to 50 MHz on signals 0.5 V p-p or more, increasing to 1 V p-p at 100 MHz.

Line: power line frequency signal.

Level and slope: internal, at any point on the vertical waveform displayed; external, variable from +3 V to −3 V on either slope of the sync signal; from +30 V to −30 V in ÷10 setting.

Coupling: (AC, DC, ACF, or ACS). AC attenuates signals below ≈ 20 kHz, ACF (ac-fast) attenuates signals below ≈ 15 kHz, ACS (ac-slow) attenuates signals above ≈ 30 kHz.

Trace intensification: intensifies that part of Main time base to be expanded to full screen on Delayed time base. Rotating Delayed time base sweep switch from Off position activates intensified mode. Front panel screwdriver adjust sets relative intensity of brightened segment.

Delayed time base

Sweep

Ranges: 0.1 μs/div to 50 ms/div (18 positions) in 1, 2, 5 sequence. ±3% accuracy with vernier in CAL position.

Vernier: continuously variable between all ranges; extends slowest sweep to at least 12.5 ms/div.

Triggering: applies to intensified Main, Delayed, and Mixed time base triggering.

Internal: refer to vertical amplifier plug-in specifications.

Automatic: triggers at end of set time delay.

External: same as main time base.

Level and slope: same as main time base.

Coupling: same as main time base.

Delay (before start of Delayed sweep)

Time: continuously variable from 0.1 μs to 10 s.

Accuracy: ±1%. Linearity, ±0.2%. Time jitter, <0.005% (1 part in 20,000) of maximum delay of each step.

Trigger output: (at end of Delay time) approx 1.5 V with <50 ns risetime from 1000 ohm source resistance.

Mixed time base: dual time base in which Main time base drives first portion of sweep and delayed time base completes sweep at up to 1000 times faster. Also operates in single sweep mode.

General

Operating environment: same as 180C/D mainframes.

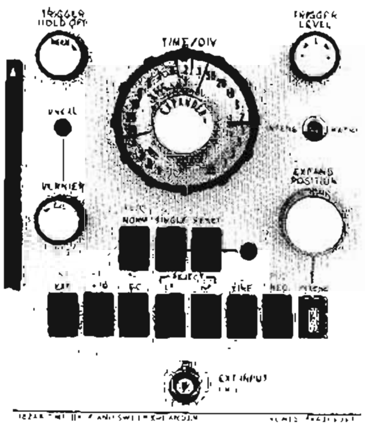
Weight: net, 4 lbs (1,8 kg); shipping, 7 lbs (3,1 kg).

Price: Model 1821A Time Base and Delay Generator, $700.

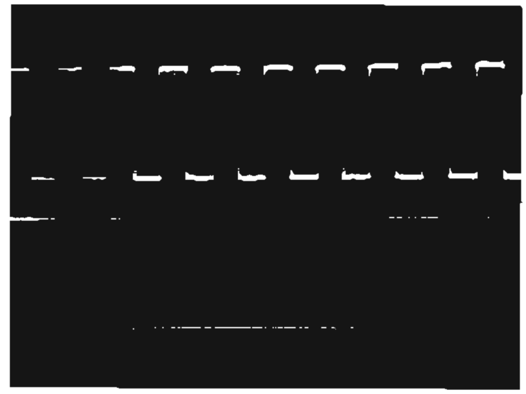
TIME BASE & X100 EXPANDER

5 ns/div sweep, 150 MHz triggering

Model 1824A



1824A



Multiple exposure shows added detail of expanded pulse.

Description, 1824A

Model 1824A time base and sweep expander plug-in is designed for use in all 180 series mainframes including the 183 wide band mainframes. This plug-in allows sweep expansions up to 100 times with 3% accuracy, 5 ns sweep speeds, and triggering to 150 MHz.

The expanded sweep feature allows detailed examination of selected portions of a display where time delay measurements are not of importance. This provides sweep expansion measurement capability without the expensive delay generator features for your applications. Expansions of 100 times are available and the time/div dial gives a direct readout of the expanded time/div, preventing many measurement errors. Convenient setup is provided by a trace intensification feature that selects the starting point of the portion of a sweep that will be expanded to full screen. Expanded sweep position is continuously variable over the center 9 divisions of the main sweep.

Pushbutton controls make operation easy with a minimum chance for error and an automatic trigger mode displays a baseline in absence of a trigger signal. A trigger hold off control provides for stable triggering on complex waveforms or a particular pulse in a digital word may be selected to trigger a display. Additional trigger flexibility is provided by complete selection of the trigger parameters which includes: ac or dc coupling, low or high frequency rejection, positive or negative slope, and a ÷10 mode that provides wider dynamic range of input signals. A trigger level control allows selection of the trigger signal at any point on the displayed signal or a ±2 volt external signal.

An external trigger input sensitivity of 50 mV adds to the versatility of this plug-in by allowing 10:1 divider probe to be used with 0.5 V logic circuits. This allows standard probes to be used to reduce circuit loading at trigger pick-off points and reduces the possibility of circuit malfunction caused by the measuring instrument.

Specifications, 1824A

Time base

Sweep

Ranges: 50 ns/div to 1 s/div (23 calibrated positions) in 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between ranges, extends slowest sweep to at least 2.5 s/div. Uncalibrated light indicates when vernier is not in calibrated position.

Magnifier: (on mainframe) expands fastest sweep to 5 ns/div.

Expanded sweep

Expander: direct reading expander control provides up to 100 times sweep expansion, accuracy ±3%. Expand position control selects part of basic time scale to be expanded, continuously variable from <0.5 div of sweep start to >8.5 div of basic time scale.

Trace intensification: front panel switch selects intensified mode for use in establishing start of expanded display. A front panel adjustment sets relative intensity of brightened segment.

Sweep mode

Normal: sweep is triggered by an internal, external, or power line signal.

Automatic: bright baseline displayed in absence of input signal. Triggering same as Normal except low frequency limit is 40 Hz.

Single: in normal, sweep occurs once with same triggering as Normal; reset pushbutton arms sweep and lights indicator; in Auto, sweep occurs once each time reset pushbutton is pressed.

Triggering

Internal: refer to vertical amplifier plug-in specifications.

External: dc to 50 MHz on signals of 50 mV p-p or more, increasing to 100 mV p-p at 100 MHz and 150 mV p-p at 150 MHz.

Line: power line frequency signal.

Level

Internal: at any point on the vertical waveform displayed.

External: continuously variable from +2 V to −2 V on either slope of trigger signal; from +20 V to −20 V in ÷10 setting.

Slope: pushbutton selects either positive or negative slope of trigger signal.

Coupling: front panel selection of AC, DC, HF Reject or LF Reject.

AC: attenuates signals below approx 20 Hz.

LF Reject: attenuates signals below approx 15 kHz.

HF Reject: attenuates signals above approx 15 kHz.

Trigger holdoff: time between sweeps continuously variable. Exceeds one full sweep on all ranges.

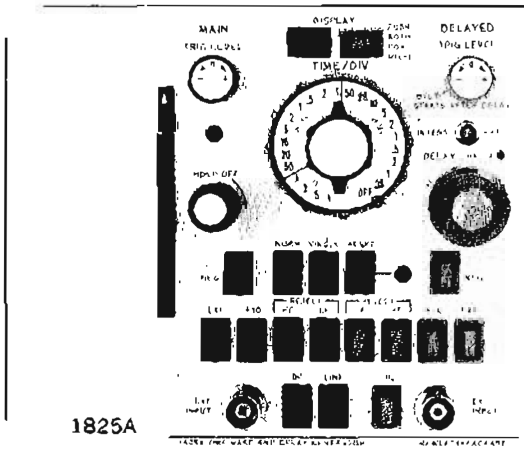
General

Operating environment: same as 180C/D mainframes.

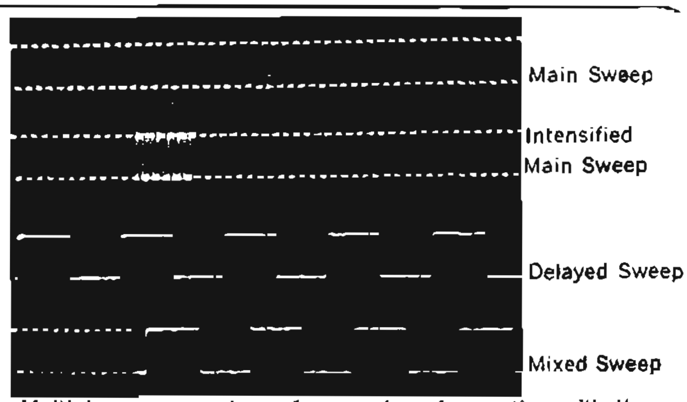
Weight: net, 3 lb (1,4 kg); shipping, 7 lb (3,2 kg).

Price: Model 1824A Time Base and Sweep Expander, $550.

DELAYED SWEEP GENERATOR
5 ns/div sweep, 150 MHz triggering
Model 1825A



1825A



Multiple exposure shows four modes of operation with time relationship maintained in all modes.

Description, 1825A

Model 1825A time base and delay generator provides sweep speeds ranging from 0.05 μs/div to 1 s/div in 23 positions. Delay times are continuously variable from 50 ns to 10 s and are accurate to ±1% also a calibrated mixed sweep mode is provided. A mainframe X10 magnifier provides sweep-speeds to 5 ns/div with 5% accuracy.

One knob control makes stable triggering on signals easy in main, delayed, and mixed modes. Stable, accurate time displays are provided in main, delayed, and mixed modes with the highly sensitive 50 mV trigger capability at 50 MHz which increases to only 150 mV at 150 MHz. Trigger synchronization is maintained when switching between main, delayed, and mixed modes further simplifying use.

Front panel controls are logically arranged for quick familiarization and easy use. Pushbuttons eliminate front panel clutter and reduce the possibility of errors. Sweep mode pushbuttons make it easy to establish main, delayed, and mixed modes.

Trigger level controls on main and delayed sweeps allow selection on the desired portion of the signal for almost every measurement application. Also, the ÷10 function provides a wide dynamic range of triggering in both external and internal modes of operation.

External trigger sensitivity of 50 mV on both main and delayed sweeps allows a 10:1 divider probe to be used with 0.5 volt logic circuits. This allows probes to be used to reduce circuit loading at trigger pickoff points and reduces the possibility of circuit malfunction caused by the measuring instruments.

Specifications, 1825A

Main time base

Sweep

Ranges: 0.05 μs/div to 1 s/div (23 positions) in 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between ranges, extends slowest sweep to at least 2.5 s/div. Uncalibrated light indicates when vernier is not in CAL position.

Magnifier: (on mainframe) expands fastest sweep to 5 ns/div.

Sweep mode

Normal: sweep is triggered by an internal, external, or power line signal.

Automatic: bright baseline displayed in absence of trigger signal. Triggering is same as Normal except low frequency limit is 40 Hz.

Single: in Normal, sweep occurs once with same triggering as Normal; reset pushbutton arms sweep and lights indicator; in Auto, sweep occurs once each time reset pushbutton is pressed.

Delayed time base: delayed time base sweeps after a time delay set by Main time base and Delay controls. Delayed time base is triggered on first triggering pulse after set delay or automatically triggers after set delay when delayed level control is in detent position.

Sweep

Ranges: 0.05 μs/div to 20 ms/div (18 positions) in 1, 2, 5 sequence. ±3% accuracy.

Magnifier: (on mainframe) expands fastest sweep to 5 ns/div.

Triggering: Main or Delayed time base.

Internal: refer to vertical amplifier plug-in specifications.

External: dc to 50 MHz on signals 50 mV p-p or more increasing to 100 mV p-p at 100 MHz and 150 mV p-p at 150 MHz.

Line: power line frequency signal. (Main only.)

Level

Internal: at any point on the vertical waveform displayed.

External: continuously variable from +2 V to −2 V on either slope of trigger signal, from +20 V to −20 V in ÷10 setting.

Slope: pushbutton selects either positive or negative slope of trigger signal.

Coupling: front panel selection of AC, DC, HF Reject, or LF Reject.

AC: attenuates signals below approx 20 Hz.

LF Reject: attenuates signals below approx 15 kHz.

HF Reject: attenuates signals above approx 15 kHz.

Trigger holdoff: time between sweeps continuously variable, exceeding one full sweep on all ranges. (Main only.)

Delay (before start of delayed sweep)

Time: continuously variable from 50 ns to 10 s.

Accuracy: ±0.75% of differential delay, ±2 div of delay dial.

Time jitter: 0.002% (1 part in 50,000) of maximum delay on each range.

Trace intensification: in Main sweep mode, intensifies that part of main time base to be expanded to full screen in delayed time base mode. In Mixed mode, intensifies that part of Main time base to be completed by Delayed time base. Rotating time base switch from OFF position activates intensified mode.

Calibrated mixed sweep: combines Main and Delayed sweeps into one display. Sweep is started by the Main time base and is completed by the faster Delayed time base. Delayed sweep start is aligned with start of intensified marker.

General

Operating environment: same as 180 C/D mainframes.

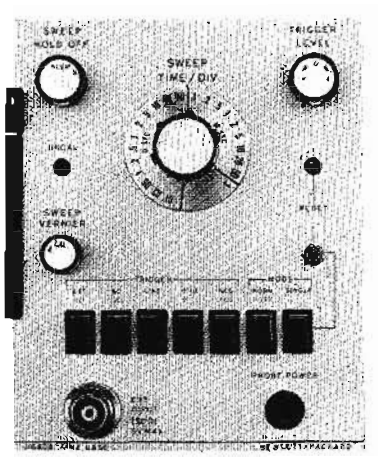
Weight: net, 4 lbs (1,8 kg); shipping, 7 lbs (3,1 kg).

Price: Model 1825A Time Base and Delay Generator, $800.

TIME BASE

1 ns/div sweep; 500 MHz triggering

Model 1840A



1840A

- 1 knob triggering to 500 MHz
- 50 mV trigger sensitivity
- 1 ns/div sweep speeds
- Simplified front panel controls

Description, 1840A

The 1840A Time Base provides stable one knob internal triggering from an 1830A to 250 MHz or from an 1831B to 500 MHz. External triggering to 250 MHz is provided with 20 mV input and increases to 500 MHz with 50 mV input signals. Trigger functions are controlled with convenient push-buttons which simplify panel layout and operation. A variable hold off control achieves a stable display of pulse groups by allowing triggering on a particular pulse in a group.

Sweep times are selectable from 10 ns/div to 0.1 sec/div and with the mainframe X10 magnifier a sweep speed of 1 ns/div is available. The single sweep mode of operation in the 1840A is fully compatible with the 183 pulsed flood gun mode of operation which increases photographic writing speed. Fast single-shot events can be photographed and the film "post fogged" by synchronizing flood gun operation with the single sweep, which allows the camera shutter to be left open for the event.

Option 001 for the 1840A is available for applications involving high amplitude external trigger signals. This option provides selectable trigger levels of ±5 volts or ±25 volts and will withstand peak input pulses of 100 volts with 10 μs duration.

Specifications, 1840A

Time base

Sweep

Ranges: from 10 ns/div to 0.1 s/div in 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between all ranges, extends slowest sweep to at least 0.25 s/div.

Magnifier (on mainframe): extends fastest sweep to 1 ns/div with ±5% accuracy.

Sweep mode

Normal: sweep is triggered by an internal, external, or power line signal.

Automatic: bright baseline displayed in absence of trigger signal.

Single: sweep occurs once with Normal trigger conditions. Sweep may be reset with front panel pushbutton or electrically with rear panel input signal. Front panel light indicates when sweep is reset.

Triggering

Internal: refer to vertical amplifier plug-in specifications.

External: dc* to >250 MHz with signals of 20 mV p-p or more increasing to 50 mV, at 500 MHz. Input R, 50 ohms. ÷10 trigger attenuator allows wider dynamic range of Ext trigger input.

*(Automatic triggering is same as normal except low frequency limit is 5 Hz for internal and external triggering.)

Line: power line frequency trigger signal.

Level and slope

Internal: at any point on the displayed vertical waveform.

External: continuously variable from −100 mV to +100 mV in ÷1 and +1.0 V to −1.0 V in ÷10. Input R, 50 ohms nominal.

Coupling: front panel selection of ac or dc. AC attenuates signals below approx 5 kHz.

Sweep hold off: time between sweeps continuously variable exceeding one full sweep on all ranges.

General

Probe power: provides power for operating one Hewlett-Packard active probe.

Weight: net, 3 lbs (1,4 kg); shipping, 6 lbs (2,7 kg).

Operating environment: same as Model 183 mainframe.

Price: Model 1840A Time Base, $700.

Options (order by option number)

001: contains attenuation and limiting circuits in the external trigger input which allows wider dynamic range of EXT trigger input levels. Specifications for the Model 1840A Option 001 are the same as Model 1840A except as follows:

External trigger input

÷1 mode: 1 V p-p to 250 MHz, trigger level adjustable over ±5 volt range.

÷5 mode: 5 V p-p to 250 MHz, trigger level adjustable over ±25 volt range.

Maximum input: 100 V peak with 10 μs duration. Maximum continuous input, 5 V rms.

Price: Model 1840A Option 001, Time Base, add $50.

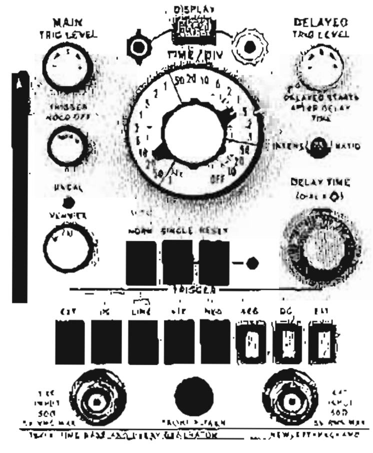
035: eliminates sweep irregularities caused by high amplitude signals necessary for the 1831A and 1831B direct access plug-ins. This option is required for operation with 1831A or 1831B plug-ins and also requires a 183 mainframe with Option 035. No additional charge.

DELAYED SWEEP GENERATOR

1 ns/div sweeps; 500 MHz triggering

Model 1841A

- 1 knob *triggering* to 500 MHz
- 1 ns/div main and delayed sweeps
- Simplified front panel controls
- Indicator lights for sweep modes



1841A

Description, 1841A

Mode 1841A Time Base and Delay Generator provides 21 sweep times ranging from 10 ns/div to 0.1 s/div. Delay times are selected by a calibrated 10-turn control across the time range set by the sweep time switch. A *mainframe x10 magnifier* provides 1 ns/div sweep times for both main and delayed sweeps to match the CRT writing speed.

One knob control makes triggering on rf carriers and signals even higher than the VHF range very easy. Both main and delayed sweep circuits trigger directly on 50 mV signals to 500 MHz without countdown procedures. Trigger synchronization is also maintained when switching from main to delayed or delayed to main sweeps.

Front panel controls are logically arranged for quick familiarization and easy use. Pushbutton controls for trigger functions eliminate front-panel clutter and reduce the chance for error. Sweep time controls are arranged to make it easy to read main and delayed sweep times at a glance and color coding on main and delayed controls clearly differentiate one sweep from the other. Also, front panel lights indicate the main or delayed mode of operation.

Specifications, 1841A

Main time base

Sweep

Ranges: from 10 ns/div to 0.1 s/div (22 positions) in 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between all ranges, extends slowest sweep to at least 0.25 s/div.

Magnifier (on mainframe): extends fastest sweep to 1 ns/div, ±5%.

Sweep mode

Normal: sweep is triggered by an internal, external, or power-line signal.

Automatic: bright baseline displayed in absence of a trigger signal.

Single: sweep occurs once with same triggering as normal; reset pushbutton with armed indicator light. Rear panel input (on mainframe) provides remote arming capability.

Triggering

Internal: refer to vertical amplifier plug-in specifications.

External: dc* to >250 MHz with signals of 20 mV p-p or more, increasing to 500 MHz with signals of 50 mV p-p or more. Input R, 50 ohms. Input in ÷10, from +1 V to −1 V. *(Triggering in AUTO is same as normal except low frequency limit is 5 Hz.)

Line: power line frequency trigger signal.

Level and slope

Internal: at any point on the displayed vertical waveform.

External: continuously variable from −100 mV to +100 mV in ÷1 and 1.0 V to −1.0 V in ÷10. Input R, 50 ohms nominal.

Coupling: front panel selection of ac or dc. AC attenuates signals below approx 5 Hz.

Trigger hold off: time between sweeps continuously variable, exceeding one full sweep on all ranges.

Trace intensification: used to set up delayed time base. Intensifies that part of main time base to be expanded to full screen on delayed time base. Moving delayed sweep switch from off position activates intensified mode. Front panel adjustment sets relative intensity of brightened segment.

Delayed time base

Delayed time base sweeps after the time delay set by main time base and delay controls.

Sweep

Ranges: 10 ns/div to 1 ms/div in 1, 2, 5 sequence (16 positions). ±3% accuracy.

Triggering

Internal: refer to vertical amplifier plug-in specifications.

Automatic: delayed sweep is automatically triggered at end of set delay time.

External: dc to >250 MHz with signals of 20 mV p-p or more, increasing to 500 MHz on signals of 50 mV p-p or more. Input R, 50 ohms.

Coupling: front panel selection of ac or dc. AC attenuates signals below approx 5 kHz.

Delay (before start of delayed sweep)

Time: continuously variable from 50 ns to 1 s.

Accuracy: ±1% on 50 ms to 0.1 μs, main sweep linearity ±2%, time jitter is 0.005% (1 part in 20,000) of maximum delay of each step.

General

Probe power: supplies power to operate one Hewlett-Packard active probe.

Weight: net, 3.6 lbs (1,6 kg); shipping, 7 lbs (3,2 kg).

Operating environment: same as Model 183 mainframe.

Price: Model 1841A Time Base/Delay Generator, $1150.

2 CHANNEL/1 GHz SAMPLER

Easy-to-use, internal triggering

Model 1810A

Description, 1810A

Model 1810A is a 1 GHz, dual channel double-size sampling plug-in for use in all 180 series oscilloscope mainframes. Easy-to-use controls, operate and look like real-time plug-ins which reduces familiarization time and possible measurement errors. You can make accurate measurements of repetitive signals from dc to greater than 1 GHz with deflection factors of 2 mV/div to 200 mV/div without the problems encountered with previous, specialized sampling controls.

A unique sampling circuit maintains a sampling efficiency at 100% for all input signal levels, which eliminates time consuming external adjustments and false triggering. Other internal circuit improvements reduce internal adjustments to a minimum, and they are non-interacting, for fast calibration. Internal delay lines allow triggering on the displayed waveform without requiring an external pre-trigger. By adding 50 ohm impedance converter probes, 1120A, the 1810A can be used for general purpose probing with minimum circuit loading with very low probe shunt capacitance. Power for two Hewlett-Packard active probes is provided through the front panel power jacks or an 1122A probe power supply may be used for up to four probes.

Specifications, 1810A

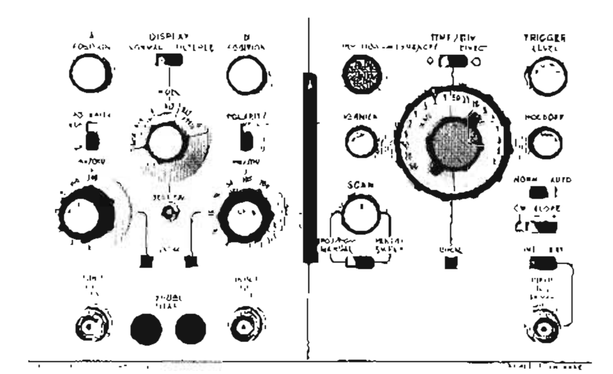
Modes of operation: channel A; channel B; channels A and B displayed on alternate samples (ALT); channel A plus channel B (algebraic addition); and channel A versus channel B.

Vertical channels

Bandwidth: dc to 1 GHz.
Rise time: <350 ps.
Pulse response: <3% (overshoot and perturbations).
Deflection factor
Ranges: 2 mV/div to 200 mV/div (7 calibrated positions) in 1, 2, 5 sequence.
Accuracy: ±3%.
Vernier: provides continuous adjustment between all deflection factor ranges; extends minimum deflection factor to <1 mV/div.
Polarity: + UP or − UP.
Dynamic range: >1.6 V.
Positioning range: >±1 V on all deflection factors.
Input R: 50 ohms, ±2%.
Maximum input: ±5 V (dc + peak ac).
VSWR: <1.1:1 to 300 MHz, increasing to <1.5:1 at 1 GHz.
Reflection coefficient: <6%, measured with HP Model 1415A TDR.
Noise
Normal: <2 mV, observed from center 80% of dots.
Filtered: <1 mV.
Isolation between channels: ≥40 dB with 350 ps rise time input.
Time difference between channels: <100 ps.
A + B operation: bandwidth and deflection factors are unchanged: either channel may be inverted for ±A±B operation.
Vertical outputs: an uncalibrated, 1 V vertical output signal from each channel is provided at the rear panel of 180 system mainframes.

Time base

Ranges
Normal: 10 ns/div to 50 μs/div (12 calibrated positions) in a 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.
Expanded: direct reading expansion up to X100 in seven calibrated steps on all normal time scales, extends the range to 100 ps/div. Accuracy is ±4% (10 ps/div, ±10% using the mainframe magnifier).
Vernier: continuously variable between ranges: increases fastest sweep to <40 ps/div.



1810A

Triggering
Mode
Normal: trigger level control can be adjusted to trigger on a wide variety of signals.
Automatic: triggers automatically on most signals with a minimum of adjustment of the level control. A baseline is displayed in the absence of an input signal.
Source: selectable; channel A triggers channel A or alternate; channel B triggers channel B, alternate, A + B, or A vs B.
Internal
Sine wave: 30 mV p-p for signals from 1 kHz to 200 MHz, 100 mV p-p for signals from 200 MHz to 1 GHz for jitter of <30 ps plus 1% of 1 period. Useful triggering can be obtained with 5 mV signals.
Pulse: 30 mV peak, 3 ns wide pulses for <30 ps jitter. Useful triggering can be obtained with 5 mV signals.
External
Sine wave: 30 mV p-p for signals from 1 kHz to 1 GHz for jitter of <30 ps plus 1% of 1 period. Useful triggering can be obtained with 5 mV signals.
Pulse: 30 mV peak, 3 ns wide pulses for <30 ps jitter. Useful triggering can be obtained with 5 mV signals.
Either internal or external
Auto: 50 mV p-p for CW signals from 10 kHz to 200 MHz for <30 ps jitter plus 2% of 1 period (may be used to 1 GHz with increased jitter). Pulse triggering requires 50 mV peak, 3 ns wide pulses for <30 ps jitter.
Level and slope: level control which minimizes jitter is variable over ±800 mV range on either slope of sync signal.
Coupling: ac coupling attenuates signals below approx 1 kHz.
Variable holdoff: variable over at least a 3:1 range in all sweep modes.
Marker position: intensified marker segment indicates point about which the sweep is to be expanded (automatically dimmed with increasing persistence in 181 and 184 mainframes).
Scan
Internal: dot density, continuously variable from <100 to >1000 dots full screen or from approx 500 to >2000 dots in filtered mode.
Manual: scan is positioned manually by front panel control.
Horizontal output: an uncalibrated approx 0.75 V amplitude signal is provided at the rear panel of a 180, 181 or 184 mainframe.

General

Probe power: supplies power to operate two Hewlett-Packard active probes.
Weight: net, 7 lbs (3,2 kg); shipping, 12 lbs (5,4 kg).
Operating environment: same as Model 181A/AR mainframes.
Price: Model 1810A 1 GHz Sampling, $1750.

2 CHANNEL/18 GHz SAMPLER
Easy-to-use, 10 ps time scale
Model 1811A

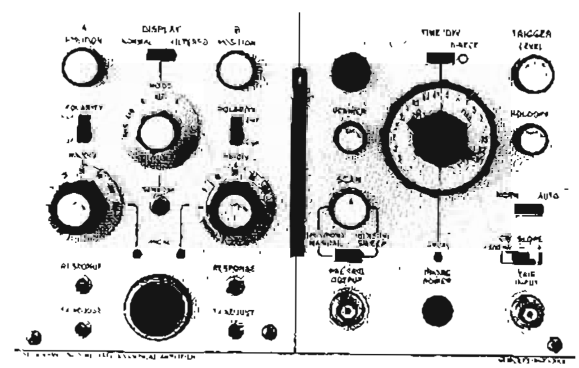
Description, 1811A

The Model 1811A sampling plug-in provides 18 GHz, dual-channel, feedthru sampling in the versatile 180 oscilloscope system. The logical arrangement of front panel controls reduces familiarization time and measurement errors and the feedthru remote sampling heads allow measurements of operating systems. Flexibility and economy is assured with this double-size plug-in since it will operate in all 180 series mainframes with a selection of standard CRTs (5-inch), large screen, variable persistence and storage, and the wideband 183 mainframes. A selection of remote sampling heads allows you to match a sampling system to a measurement problem at minimum cost.

The bridged method of extracting a signal used in this sampling system provides the optimum method of measurement since it extracts only a small amount of the waveform rather than terminating the signal in the measuring system. By using remote sampling heads connected in series with the system under test, the signal displayed is the signal that is passed through the sampler to the next stage of a system. Any problems are then displayed as they exist in the system.

The two sampling heads available are: 1430C, 1432A. Model 1432A provides 90 ps risetime capability while 18 GHz measurements are supplied by the 1430C which has a 20 ps risetime. Specifications for these sampling heads are on the following page.

18 GHz triggering with a displayed jitter of 10 ps or less is provided by a 1104A trigger countdown, 1106B tunnel diode, and 1109B high-pass filter. To allow viewing a signal without using a delay line, a trigger output is available as a signal source trigger which starts the sweep prior to display of the vertical signal.



1811A

Specifications, 1811A

Modes of operation: channel A; channel B, channels A and B displayed on alternate samples (ALT); channel A plus channel B (algebraic addition); and channel A versus channel B.

Vertical channels

Deflection factor

Ranges: 2 mV/div to 200 mV/div (6 calibrated positions) in 1, 2, 5 sequence.

Accuracy: ±3%.

Vernier: provides continuous adjustment between all deflection factor ranges; extends min deflection factor to <1 mV/div.

Polarity: + UP or − Up.

Positioning range: >±1 V on all deflection factors.

A + B operation: bandwidth and deflection factors are unchanged; either channel may be inverted for ±A ±B operation.

Time base

Ranges

Normal: 1 ns/div to 5 μs/div (12 calibrated positions) in a 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.

Expanded: direct reading expansion up to X100 in seven calibrated steps on all normal time scales, extends the range to 10 ps/div. Accuracy is ±4% (1 ps/div, ±10% using the mainframe magnifier).

Vernier: continuously variable between ranges; increases fastest unmagnified sweep to <4 ps/div.

Triggering

Mode

Automatic: triggers automatically on most signals with a minimum of adjustment of the level control. A baseline is displayed in the absence of an input signal.

Normal: trigger level control can be adjusted to trigger on a wide variety of signals.

CW: 80 mV p-p for signals from 1 kHz to 1 GHz for jitter of <10 ps plus 1% of 1 period. Useful triggering can be obtained with 5 mV signals. Triggering may be extended to 18 GHz with HP Models 1104A/1106B trigger countdown.

Pulse: 30 mV peak, 3 ns wide pulses for <30 ps jitter. Useful triggering can be obtained with 5 mV signals.

Auto: 50 mV p-p for CW signals from 10 kHz to 200 MHz for <30 ps jitter plus 2% of 1 period (may be used to 1 GHz with increased jitter). Pulse triggering requires 50 mV peak, 3 ns wide pulses for <30 ps jitter.

Level and slope: continuously variable from +800 mV to −800 mV on either slope of sync signal.

Coupling: ac coupling attenuates signals below approx 1 kHz.

Variable holdoff: variable over at least a 3:1 range in all sweep modes.

Marker position: intensified market segment indicates point about which the sweep is to be expanded (automatically dimmed with increasing persistence in 181 and 184 mainframes).

Scan

Internal: dot density, continuously variable from <100 to >1000 dots full screen or from approx 500 to >2000 dots in filtered mode.

Manual: scan is positioned manually by front panel control.

Trigger output: 1 ns, 1.5 V into 50 ohms.

General

Recorder outputs

Vertical: an uncalibrated, 1 V vertical output signal from each channel is provided at the rear panel of 180 series mainframes.

Horizontal: an uncalibrated approx 0.75 V amplitude signal is provided at the rear panel of 180, 181, or 184 mainframes.

Probe power: supplies power to operate one Hewlett-Packard active probe.

Environment: same as Models 180C/D mainframes.

Weight: net, 5 lbs (2,3 kg); shipping, 10 lbs (4,5 kg).

Price: Model 1811A Sampler, $1700.

FEED THRU SAMPLING HEADS
4 or 18 GHz, Low reflection coefficients
Models 1430C, 1432A

Description, sampling heads

Models 1430C and 1432A provide accurate measurements of CW and fast rise pulses. The sampler is of feedthru design allowing measurements to be made using the system as a load rather than using an artificial internal termination. These remote samplers are connected to the scope by a five-foot cable which allows the head to be placed at the signal source to eliminate high frequency lossy lines.

Model 1430C provides 20 ps rise time with low overshoot for accurate measurements of fast rise pulses and CW signals to 18GHz. While the feedthru measurement technique allows measurements of an operating system, terminated measurements can also be made with the 50 ohm loads (Model 909A Option 012) that are supplied.

The 1432A provides 90 ps risetime (4 GHz) measurements for lower frequency measurements than the 1430C. Feedthru or terminated measurement may also be obtained with this sampler and the two 50 ohm loads that are supplied.

Specifications, 1430C

Rise time: approx 20 ps (<28 ps observed with 1105A/1106B pulse generator and 909A Option 012 50 ohm load).
Bandwidth: dc to 18 GHz.
Overshoot: <7.5%.
Noise: 10 mV unsmoothed; 2.5 mV smoothed. Both measured tangentially.
Dynamic range: ±1 volt.
Low frequency distortion: <±5%.
Maximum safe input: ±3 volts.
Input characteristics
Mechanical: type N connectors on input and output ports.
Electrical: 50 ohm feedthrough, dc-coupled. Reflection from sampler is approx 10%, measured with a 40 ps TDR system. Pulses emitted from sampler input are approx 10 mV amplitude and 5 ns duration.
Time difference between channels: <5 ps.
Isolation between channels: ≥40 dB over sampler bandwidth.
Connecting cable lengths: 5 ft.

General

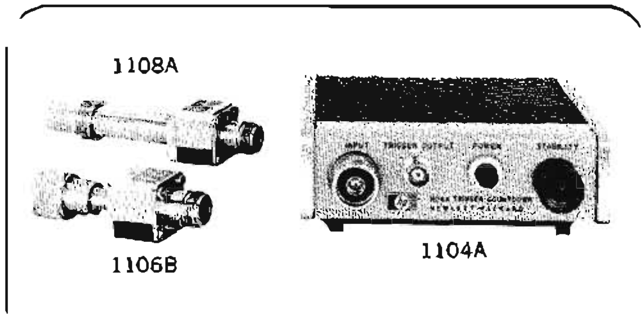
Weight: net, 4 lbs (1,8 kg); shipping, 9 lbs (4,1 kg).
Accessories provided: two 50 ohm loads (HP Model 909A Option 012).
Price: Model 1430C Sampling Head, $2800.

Specifications, 1432A

Rise time: <90 ps.
Bandwidth: dc to 4 GHz.
Overshoot: <±5%.
Noise: approx 8 mV observed noise on CRT excluding 10% of random dots. Noise decreases on automatically filtered ranges of 5 and 2 mV/div. Smoothed position of smoothing switch reduces noise and jitter approx 4:1. Response provides continuous adjustment between normal and filtered modes.
Dynamic range: 1 V p-p.
Low frequency distortion: <3%.
Maximum safe input: ±5 V.
Input characteristics
Mechanical: GR type 874 connectors on input and output ports.
Electrical: 50 ohm feedthrough, dc-coupled. Reflection from sampler is approx 15% measured with a 90 ps TDR system. Pulse emitted from sampler input are approx 50 mV in amplitude and 10 ns wide.
Time difference between channels: <25 ps.
Isolation between channels: ≥40 dB over sampler bandwidth.

General

Weight: net, 4 lbs (1,8 kg); shipping, 9 lbs (4,1 kg).
Accessories provided: two 50 ohm loads with GR type 874 connectors.
Price: Model 1432A Sampling Head, $1185.



Specifications, 1104A/1106B/1108A
1104A/1106B/18 GHz Trigger Countdown
1104A/1108A/10 GHz Trigger Countdown

Input

Frequency range: (1106B) 1 GHz to 18 GHz. (1108A) 1 GHz to 10 GHz.
Sensitivity: (1106B) signals 100 mV or larger and up to 12.4 GHz, produce <20 ps of jitter (200 mV required to 18 GHz). (1108A) signals up to 50 mV or larger and up to 10 GHz, produce <20 ps of jitter.
Maximum safe input: ±1 V.
Input impedance: (1106B) 50-ohm Type N input connector. (1108A) 50-ohm GR-874 input connector. Reflection from input connector is <10% using a 40 ps TDR system.
Signal appearing at input connector: approximately 250 mV.

Output

Center frequency: approximately 100 MHz.
Amplitude: typically 150 mV.

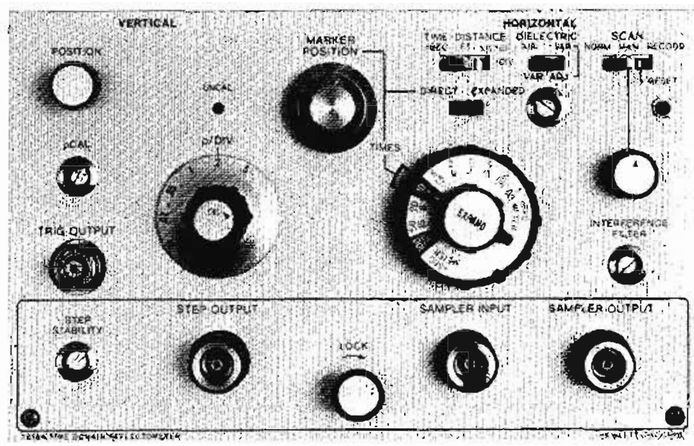
General

Weight
1104A: net, 2 lbs (0,9 kg); shipping, 4 lbs (1,8 kg).
1106B or 1108A: net, 1 lb (0,5 kg); shipping, 2 lbs (0,9 kg).
Price: HP Model 1104A, $200. HP Model 1106B, $550. HP Model 1108A, $215.
Recommended accessory: HP Model 1109B High Pass Filter.

GENERAL PURPOSE TDR

Easy-to-use, economical, wide band TDR

Model 1818A



1818A

Description, 1818A

The 1818A TDR plug-in provides low cost, 170 ps TDR in the 180 oscilloscope system for the investigation of transmission systems, terminations, and components. The easy-to-use front panel controls provide quick, accurate displays with direct distance calibration of up to 1000 feet or 300 meters and dielectric materials from $\varepsilon = 1.0$ (air) to $\varepsilon = 4.0$. This double-size plug-in provides a lightweight, wideband TDR system for checkout of shipboard, airborne, and remote communications equipment.

Using a "closed-loop radar" approach for investigation of a transmission system's fidelity, this system directly displays the location and magnitude of discontinuities in an analog or digital communication system. Information is lost when a signal encounters a discontinuity that causes energy to be reflected to the source. These reflections not only cause loss of amplitude in the received information but the re-reflection from discontinuities also appear as noise that is in the same format as the original signal which, if carried to extremes, could completely garble the information. This demonstrates the need for test equipment that can locate and display individual discontinuities in distance (time) and amplitude (Rho) for fast system setup or repair. While there are many instruments that can detect the presence of discontinuities, only TDR can quickly display them to allow a technician to repair them with minimum system downtime. TDR can also be used to determine the fidelity of a termination and can also be used, in the transmission mode, to determine the transmission quality of an amplifier or attenuator. In this mode of operation, the step generator signal source is applied to the device under test and the output is detected by the sampling portion of the plug-in. In the stimulous response mode, the 1818A use the 50 ps step generator as a stimulous and the 150 ps sampling section displays the device response. This allows a waveform to be examined for risetime, delay, and pulse top abberations. The 1818A TDR plug-in is designed for use in troubleshooting systems to provide quick, easy location of discontinuities that degrade system operation.

Specifications, 1818A

System (in reflectometer configuration)

Risetime: <170 ps.
Overshoot: ≤5% overshoot and ringing (down to ½% in 3 ns).
Internal reflections: <10% (does not limit resolution).
Reflectometer sensitivity: reflection coefficients as small as 0.001 can be observed.

Signal channel

Rise time: approx. 150 ps.
Reflection coefficient: 0.5 div to 0.005/div in a 1, 2, 5 sequence.
Input: 50 ohms, feedthrough type.
Noise: 0.1% of step (terminated in 50 ohms).
Dynamic range: ±0.5 volt.
External signal level: up to 1 V peak may be safely applied to the SAMPLER OUTPUT connector.
Attenuator accuracy: ±3%.

Step generator

Amplitude: approx 0.25 V into 50 ohms (0.5 V into open circuit).
Risetime: approx 50 ps.
Output impedance: 50 ohms ±1 ohm (dc-coupled).
Droop: <1% in 1 μs.

Distance/time

Distance scale: 10 ft/div and 100 ft/div; 3 meters/div and 30 meters/div. Accuracy, ±3%.
Variable dielectric: $\varepsilon = 1$ to $\varepsilon = 4$.
Time scale: 10 ns/div to 100 ns/div. Accuracy, ±3%.
Magnification: X1 to X100 in a 1, 2, 5 sequence provides time scales down to 0.1 ns/div and distance scales to 0.1 ft/div or 0.03 meters/div. Accuracy of the basic sweep is maintained at all magnifier settings.
Delay control: 0 to 10 div of unmagnified sweep. Accuracy ±3%.
Jitter: <20 ps.

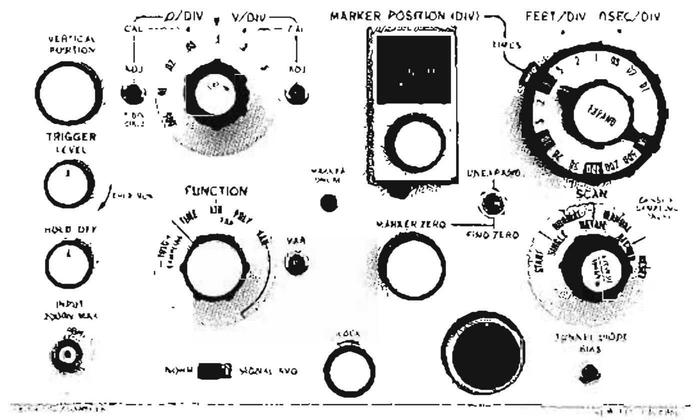
General

Operating environment: same as Models 180C/D mainframes, with exception of temperature, 0°C to 35°C (35°C to 55°C with small increase in system risetime).
Weight: net, 3 lbs (1,4 kg); shipping, 7 lbs (3,2 kg).
Price: Model 1818A Time Domain Reflectometer . $1200
Accessories supplied: Type N connector assembly. One 50 ohm load with Type N connector.

HIGH RESOLUTION TDR

35 ps TDR system/12.4 GHz sampling

Models 1815A, 1815B, 1816A, 1817A



1815A

Descriptions, 1815A,B; 1816A; 1817A

Calibrated 35 ps risetime time domain reflectometery and 12.4 GHz (28 ps risetime) sampling capabilities are available as part of the versatile 180 system oscilloscope.

The Model 1815A TDR/Sampler plug-in, a double-sized plug-in for the 180 system, can be combined with appropriate remote sampler head and tunnel diode mount to obtain a calibrated TDR system with a system risetime of 35 ps for high-resolution displays. Direct readout in feet along the line is obtained from the 1815A or in meters from the Model 1815B. Either an 1106B (20 ps) or 1108A (60 ps) tunnel diode mount is compatible for TDR with the plug-in and samplers.

The same plug-in and sampler heads used for TDR measurements also serve as either a 4 GHz or 12.4 GHz sampling system with a direct readout in time. For sampling use, there is direct triggering to 500 MHz and to 18 GHz with the Model 1104A/1106B trigger countdown.

Sampling heads, Model 1816A (90 ps risetime) and Model 1817A (28 ps risetime), are detachable, remote, single channel, feed-through samplers for convenient use in 50-ohm transmission systems. The plug-in and sampler heads provide the circuits for operating the tunnel diode pulse generators.

This calibrated TDR system allows analysis of coaxial microwave components, identifying discontinuities on the order of 0.25 inch apart. Typical components that can be analyzed are connectors, adapters, coaxial-to-circuit board transitions, loads, etc. Direct read-out in reflection coefficient, feet, or meters (optional) makes measurements faster and easier to interpret. Front panel calibration for air and polyethylene dielectrics is standard. In addition, the control allows variable calibration for different dielectrics from $\varepsilon = 1$ to $\varepsilon =$ approx 4.

Specifications, 1815A/B

Unless otherwise indicated, TDR and sampling performance specifications are the same. Where applicable, TDR specification is given first, followed by Sampler specification in parentheses. Model 1815A is calibrated in feet and 1815B is calibrated in meters.

Vertical

Scale: reflection coefficient ρ (volts) from 0.005/div to 0.5/div in 7 calibrated ranges; 1, 2, 5 sequence.

Accuracy: ±3%; TDR only, ±5% on 0.01/div and 0.005/div in signal average mode.

Vernier: provides continuous adjustment between ranges; extends scale to >0.002/div.

Signal average: reduces noise and jitter approx 2:1.

Horizontal

Scale: provides up to a 10,000 foot or meter display window with round-trip time or distance (time) in four calibrated decade ranges of 1/div, 10/div, 100/div, and 1000/div. Concentric expand control provides direct read-out in 28 calibrated steps in 1, 2, 5 sequence from 0.01 ns/div to 1000 ns/div or from 0.01 foot or meter/div to 1000 feet or meters/div (0.1 ns/div to 1000 ns/div).

Accuracy: time, ±3%; distance, TDR only, ±3% ± variations in propagation velocity.

Marker position: indicator, calibrated in divisions; provides direct read-out of round-trip time or distance (time), number of divisions x decade range in units/div.

Marker zero: ten-turn control provides variable reference for marker position dial; allows direct read-out of round-trip time or distance (time) between two or more displayed events.

Zero finder: permits instant location of marker reference.

Dielectric, TDR only: calibrated for air, $\varepsilon = 1$, and for polyethylene, $\varepsilon = 2.25$. Also provides variable settings for dielectric constants $\varepsilon = 1$ to $\varepsilon =$ approx 4.

Triggering sampling only

- **Pulses:** <50 mV for pulses 5 ns or wider for jitter <20 ps.
- **CW:** signals from 500 kHz to 500 MHz require at least 80 mV for jitter <2% of signal period plus 10 ps; usable to 1 GHz. CW triggering may be extended to 18 GHz with HP Models 1104A/1106B trigger countdown.

General

Recorder outputs: approx 100 mV/div; vertical and horizontal outputs at BNC connectors on rear panel of mainframe.

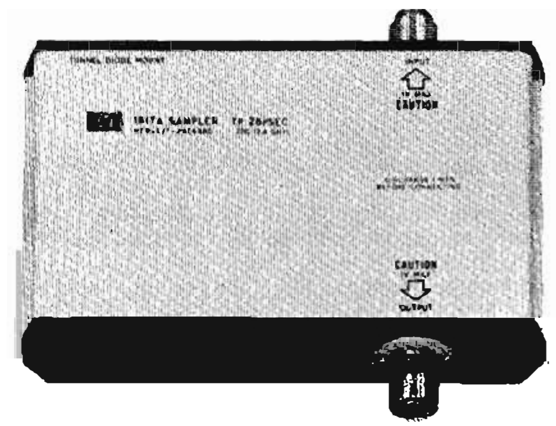
Display modes: repetitive scan, normal or detail; single scan; manual scan; record.

Environment: same as Model 181A/AR mainframes.

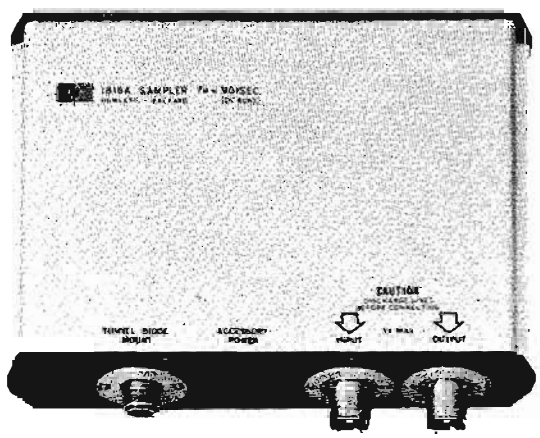
Weight: net, 5 lbs (2,3 kg); shipping, 10 lbs (4,5 kg).

Price

Model 1815A TDR/Sampler (calibrated in feet)	$1250
Model 1815B TDR/Sampler (calibrated in meters)	$1250



1817A



1816A

28ps and 90ps Sampling Heads
Specifications, 1817A and 1816A

Unless otherwise indicated, Model 1817A and 1816A specifications are the same. Where applicable, Model 1817A specifications with an 1106B tunnel diode mount are given first followed by Model 1816A specifications (in parentheses) with an 1108A tunnel diode mount.

TDR system (requires 1106B or 1108A)

System risetime: <35 ps (110 ps) incident as measured with Model 1106B (Model 1108A).

Overshoot: $<\pm 5\%$.

Internal reflections: <10% with 45 ps (145 ps) TDR; use reflected pulse from shorted output.

Jitter: <15 ps; with signal averaging, typically 5 ps.

Internal pickup: $\rho \leq 0.01$.

Noise: measured tangentially as a percentage of the incident pulse when terminated in 50 ohms and operated in signal averaging mode. <1% (0.5%) on 0.005/div to 0.02/div; <3% (1%) on 0.05/div to 0.5/div.

Low frequency distortion: $\leq \pm 3\%$.

Maximum safe input: 1 volt.

Tunnel diode mount: direct connection of 1108A to 1816A; 1106B requires an adapter, type N male to APC-7 (HP P/N 1250-0749), to connect 1106B to 1817A.

Sampler system

Risetime: <28 ps (90 ps).

Input: 50 ohm feedthrough.

Dynamic range: 1 V p-p.

Maximum safe input: 3 volts (5 volts).

Low frequency distortion: $\leq \pm 3\%$.

Noise

Normal: <8 mV (3 mV) tangential noise on 0.01 V/div to 0.5 V/div. Noise decreases automatically on 0.005 V/div range.

Signal average: reduces noise and jitter approx 2:1.

Accessories supplied

Cable, plug-in to sampler: connects sampler (1816A or 1817A) to plug-in (1815A or B), HP Part No. 5060-0441; replacement price, $75.

Cable, tunnel diode to sampler: connects tunnel diode (1106B or 1108A) to sampler, HP Part No. 01817-61603.
Replacement price $18.

General

Weight: net, 3 lb (1,4 kg); shipping, 11 lb (5 kg).

Price

Model 1817A 28 ps Rise Time Sampling Head $1500
Model 1816A 90 ps Rise Time Sampling Head $ 850

Recommended accessories

Type N male to APC-7 adapter to connect 1106B to 1817A for TDR system, price $75.

External trigger source for sampling system for triggering above 500 MHz.
10 GHz trigger countdown, 1104A/1108A price $415.
18 GHz trigger countdown, 1104A/1106B price $750.

Tunnel diode mounts
Specifications, 1106B and 1108A

Tunnel diode is required for a TDR system. Refer to sampling head specifications for mounting requirements.

Amplitude (both): >200 mV into 50 ohms.

Risetime: Model 1106B approx 20 ps; Model 1108A, <60 ps.

Output impedance: 50 ohms ±2%.

Source reflection: Model 1106B <10% with 45 ps TDR; Model 1108A, <10% with 150 ps TDR.

Weight (both): net, 1 lb (0,5 kg); shipping, 3 lbs (1,4 kg).

Price: Model 1106B, $550; Model 1108A, $215.

TDR/Sampling System Equipment*

TDR SYSTEM	
35 ps tr	1815A/B, 1817A, 1106B**
110 ps tr	1815A/B, 1816A, 1108A
SAMPLING SYSTEM	
12.4 GHz***	1815A/B, 1817A
4 GHz***	1815A/B, 1816A

*Use any 180, 181, 182, 183, 184 mainframe.

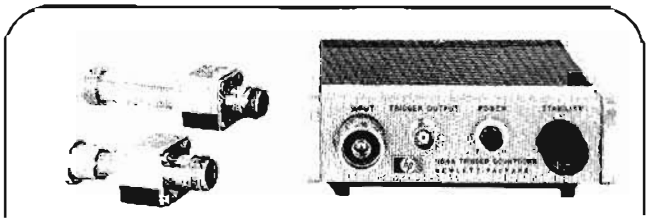
**Requires type N male to APC 7 adapter (HP P/N 1250-0749) to connect to 1817A.

***External trigger countdown, is required above 500 MHz. Recommended trigger countdowns are: 1104A/1108A to 10 GHz, 1104A/1106B to 18 GHz. A Model 1109B highpass filter is recommended for CW sampling, refer to sampling accessories.

HIGH FREQUENCY ACCESSORIES

Trigger countdown, 20/60 ps pulse generator

Models 1104A, 1105A, 1106B, 1108A, 1109B



1106B/1108A 1104A

Specifications 1104A/1106B/1108A

18 GHz Trigger Countdown
10 GHz Trigger Countdown

Input

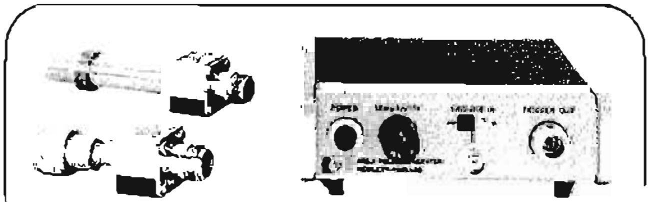
Frequency range: (1106B) 1 GHz to 18 GHz. (1108A) 1 GHz to 10 GHz.
Sensitivity: (1106B) signals 100 mV or larger up to 12.4 GHz, produce <20 ps of jitter (200 mV required to 18 GHz). (1108A) signals up to 50 mV or larger up to 10 GHz produce <20 ps jitter.
Maximum safe input: ±1 V.
Input impedance: (1106B) 50-ohm, type N input connector. (1108A) 50-ohm, GR-874 input connector. Reflection from input connector is <10% using a 40 ps TDR system.
Signal appearing at input connector: approximately 250 mV.

Output

Center frequency: approximately 100 MHz.
Amplitude: typically 150 mV.

General

Weight: 1104A: net, 2 lb (0,9 kg); shipping, 4 lb (1,8 kg); 1106B or 1108A: net, 1 lb (0,5 kg); shipping, 2 lb (0,9 kg).
Price: HP Model 1104A, $200. HP Model 1106B, $550. HP Model 1108A, $215.
Recommended accessory: HP Model 1109B High Pass Filter.



1106B/1108A 1104A

Specifications 1105A/1106B/1108A

20 ps Pulse Generator
60 ps Pulse Generator

Output

Risetime: approx 20 ps with 1106B, (<60 ps with 1108A), <28 ps observed with HP Model 1411A/1430A 28 ps Sampler and HP Model 909A Option 012, 50 ohm termination.
Overshoot: ±7.5% as observed on 1411A/1430C with 909A Option 012.
Droop: <3% in first 100 ns.
Width: approximately 3 μs.
Amplitude: >±200 mV into 50 ohms.

Output characteristics (1106B/1108A)

Mechanical: (1106B) Type N connector. (1108A) GR-874 connector.
Electrical: dc resistance; 50 ohm ±2%. Source reflection; <10%, using a 40 ps TDR system. DC offset voltage, approximately 0.1 V.

Triggering

Amplitude: at least ±0.5 V peak required.
Risetime: <20 ns required. Jitter <15 ps when triggered by 1 ns risetime sync pulse from 1424A or 1425A Sampling Time base.
Width: >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 ohm cable with Type N connectors, HP Model 10132A.
Weight: 1106B or 1108A: net, 1 lb (0,5 kg); shipping, 2 lb (0,9 kg). 1105A: net, 2 lb (0,9 kg); shipping, 4 lb (1,8 kg).
Price: HP Model 1105A, $200. HP Model 1106B, $550. HP Model 1108A, $215.

1109B High Pass Filter

1109B High Pass Filter transmits only frequencies above 1 GHz. It's useful for blocking the 100 MHz "kickout" encountered when using a tunnel diode countdown to view high frequency signals on a sampling oscilloscope.

1109B Specifications

Lower bandwidth limit: 3 dB down at GHz, nominal.

Input characteristics

Mechanical: Type N connector.
Electrical (with output terminated in 50 ohms)
Reflection: <10% using 40 ps TDR system.
VSWR: typically 1.1:1 up to 10 GHz increasing to 2:1 at 15 GHz.
DC resistance: 50 ohms ±2% shunted across line.
Weight: net, 5 oz (0,14 kg).
Price: $200.

Other sampling accessories

50-ohm loads: Model 908A, Option 012, $70.
50-ohm adapter: Model 11524A; has Type N female and APC-7 connectors. Price, $70.
Air line extensions: Model 11566A; 10 cm, APC-7 connector. Model 11567A; 20 cm, APC-7 connector. Price, $115 each.

Adapters GR Type 874

Part No.	Description	Price
0950-0090	GR Type 874 to 50 ohm Termination	$ 55.00
1250-0239	GR Type 874 to GR Type 874, 90° elbow	42.00
1250-0240	GR Type 874 to Type N female	15.00
1250-0847	GR Type 874 to Type N male	15.00
1250-0849	GR Type 847 to BNC male	15.00
1250-0850	GR Type 874 to BNC female	15.00
1250-1206	GR Type 874 to Type C male	24.00
1250-1207	GR Type 874 to Type HN female	26.00
1250-1208	GR Type 874 to Type C female	26.00
1250-1209	GR Type 874 to TNC female	26.00
1250-1210	GR Type 874 to TNC male	35.00
1250-1211	GR Type 874 to Type HN male	30.00

Adapters Type N

Part No.	Description	Price
1250-0077	Type N female to BNC male	$ 6.00
1250-0082	Type N male to BNC female	10.00
1250-0176	Type N male to Type N female right angle	6.50
1250-0240	Type N female to GR Type 874	15.00
1250-0749	Type N male to APC-7	75.00
1250-0750	Type N female to APC-7	75.00
1250-0778	Type N male to Type N male	20.00
1250-0846	Type N female tee	5.00
1250-0847	Type N male to GR Type 874	15.00

Adapters SMA

Part No.	Description	Price
1250-1007	SMA female to APC-7	$120.00
1250-1012	SMA male to APC-7	130.00
1250-1158	SMA male to SMA male	7.50
1250-1159	SMA female to SMA female	8.50

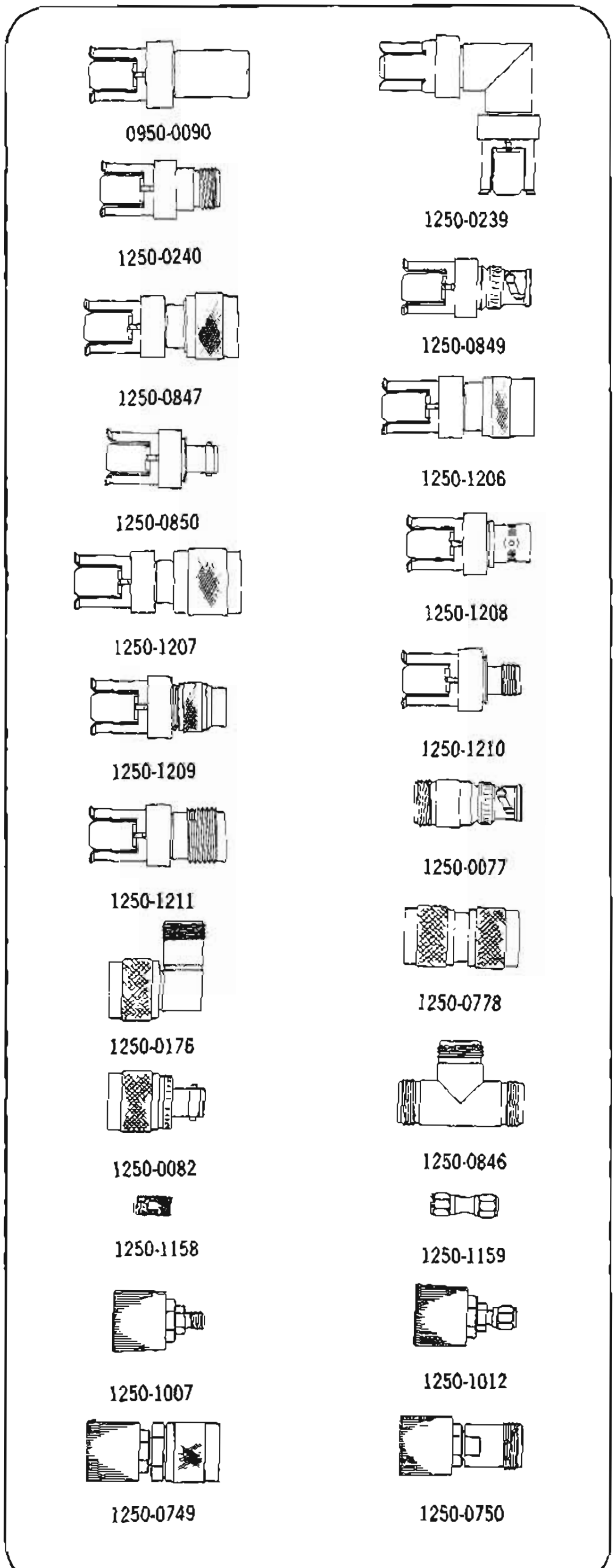
Adapters APC 7

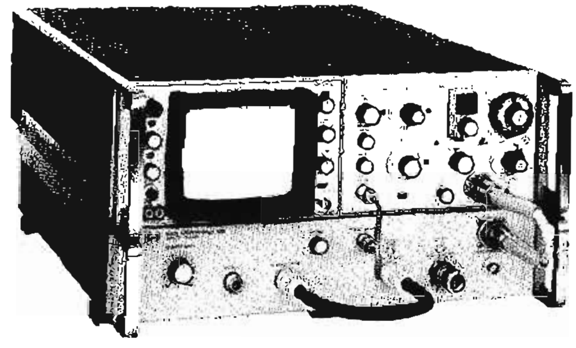
Part No.	Description	Price
1250-0749	APC-7 to Type N male	$ 75.00
1250-0750	APC-7 to Type N female	75.00
1250-1007	APC-7 to SMA male	120.00
1250-1012	APC-7 to SMA female	130.00

NARROWBAND TDR

Test waveguide systems, compact, transportable

Model 1580A





1580A

Description, 1580A

Model 1580A Narrow Band TDR System provides a quick, portable method of determining the location and magnitude of discontinuities in waveguide or bandpass coaxial transmission systems. Narrowband TDR clearly shows the magnitude of resistive or reactive discontinuities with the location directly calibrated in feet or meters from the source. This allows rapid system set-up or repair of faults caused by misaligned or corroded waveguide flanges and coaxial cable connectors, foreign objects inside waveguides, and crushed or bent waveguide or coaxial cable.

Narrowband TDR is similar in concept to radar, in that an rf pulse burst is transmitted down a system and, if a discontinuity exists, energy is reflected back to the source and is detected and displayed by the 1580A system. The use of an rf pulse burst allows the incident energy to be contained within the dominant mode of the waveguide or the passband of a narrowband system, which increases sensitivity and resolution of measurements when compared to a wideband TDR used for interrogation of a narrowband system.

Variable rf burst widths, from <5 to >100 ns, are provided by the 1580A which allows the incident rf burst bandwidth spectrum to be matched to the characteristics of a system being tested. Variable burst widths are useful when evaluating waveguide systems where the effects of dispersion, which causes a reflected rf burst to widen in time and lose amplitude, must be considered. The 1580A allows return losses of -40 dB and greater to be resolved when at least 70 mW of rf input power is available.

The Narrow Band TDR System consists of a standard 180AR rack model oscilloscope mainframe, a 1815A Option 001 TDR/Sampler Plug-in, and the 1580A Narrow Band TDR rf burst generator/sampler. The 1580A may also be purchased calibrated in meters at no additional cost by ordering Model 1580A Option 010.

The Model 1580A also has all the features of the Model 1815A/B, TDR/Sampling Plug-in and 1817A sampling head including dc to 12.4 GHz sampling and wideband TDR (with the addition of an external 1106B Tunnel Diode Mount) in lines as long as 10,000 feet. Also, by changing plug-ins, the mainframe can be used as a standard oscilloscope for real time measurements to 100 MHz.

For more information, contact your local Hewlett-Packard field engineer.

WAVEFORM ANALYZER

1% Calibration accuracy, programmable

Model 1150A

NEW

1150A

Description, 1150A

Model 1150A Programmable waveform Processor is a new tool for automatically characterizing complicated waveforms. For the first time hardware has been designed to specifically complement easy-to-use BASIC language measurement programs.

Basically, the Model 1150A is a fully programmable dual channel, 1 GHz sampling oscilloscope-like processor that digitizes incoming analog waveforms after counting the frequency down to 50 kHz or less. Sampler features include: 1, 2, 5, sequence on attenuators and sweep times, internal triggering to 1 GHz, ohm inputs, and signal averaging.

The 1150A operates in a remote mode under computer control or in local where the front panel controls function exactly like those on a real time oscilloscope. The number of displayed data points is programmable and can be set to 128, 256, 512, or 1024 points. Amplitude resolution is 10 bits or 1024 points.

A minicomputer or programmable calculator extends the 1150A programmable waveform processor to a completely automated analyzer having the versatility to characterize most complex waveforms. The central processor programs the 1150A ranges and settings, controls the point along the waveform where samples are taken, corrects the measurement accuracy to 1%, and calculates final results (such as: transition times, absolute voltages, propagation delays, and time intervals) specified in the users measurement program.

Write tests in less time

BASIC language programming simplifies the writing of software for testing electronic circuits since engineers or technicians with little programming experience can easily communicate with the test equipment through a high-level computer language.

Model 1150A speeds BASIC language test-writing by replacing keyboard entry of each control setting with LEARN, a pushbutton function located on the front panel. A single press of LEARN teaches the CPU all of the 1105A front panel settings. When writing a test, the programmer simply sets up the waveform to be analyzed as he would in making a manual measurement from a standard oscilloscope. All front panel functions become operable when LEARN is enabled and the 1150A operates exactly like a standard oscilloscope. When all controls are set to the desired ranges, pressing LEARN transfers these settings to the CPU where they become part of the measurement program. Since LEARN is enabled through a BASIC callable subroutine, all of the settings are stored and can be printed. After the application is written, the line containing the LEARN call statement can be deleted, which protects the system from operator intervention during the run phase of a production test.

LEARN can be especially useful during the RUN phase of a test when the waveform characteristics are unknown. By combining the LEARN call with some test logic, all settings can be automatically incremented to the proper value for analyzing the unknown waveform.

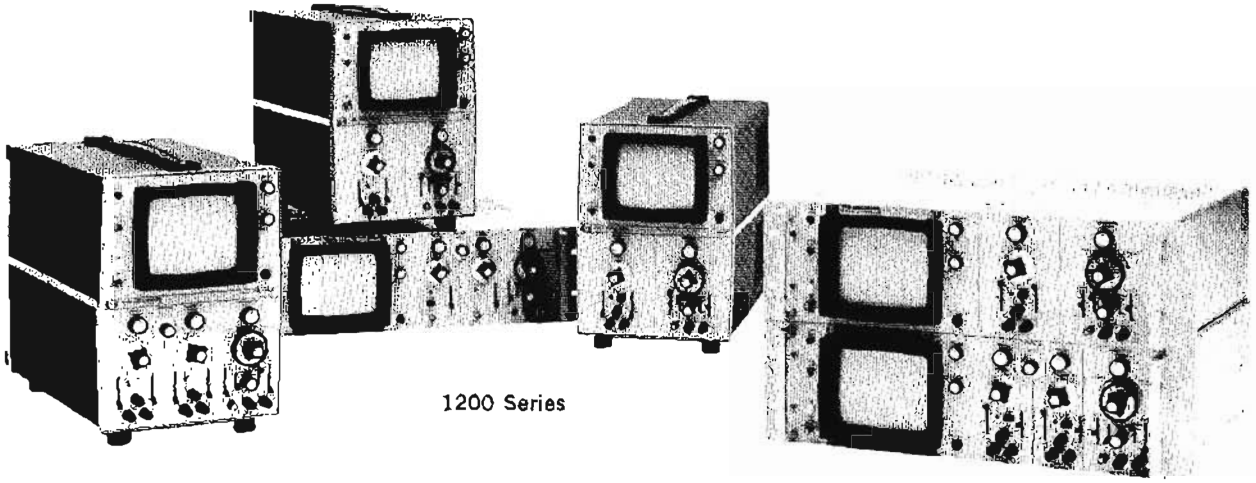
Data registers

Front panel data input and data output registers offer the programmer, operator, or repair technician a visual means of identifying 16-bit control words sent from a CPU to the 1150A and data words transferred through the 1150A to the CPU.

The data input register can be manually loaded through 16 toggle switches located just below the lamp registers. Toggle switches remain unusable until the recessed Remote/Manual slide switch is set to manual. All programmable p.c. cards and functions can be addressed through the switch register, making this a valuable service tool and means of manually addressing the calibrator and specific points in the display.

For complete information, contact your local Hewlett-Packard Field Engineer.

500 kHz, 7 MHz BANDWIDTH
Solid State—Low drift
1200 Series



1200 Series

1200 Series Description

The 1200 series 500 kHz and 7 MHz oscilloscopes provide the most versatile, general purpose instruments for today's low frequency applications. These oscilloscopes are all solid-state, light-weight, reliable, stable, which makes them ideal for a variety of applications. The many features of these scopes provide accurate, versatile, easy-to-obtain and read displays. Logical arrangement of controls, a beam finder to locate off-screen displays, and automatic triggering make operation easy, which is important to persons in production line testing, system applications, and classroom or laboratory instruction.

The wide variety of instruments assure an oscilloscope that will match your measurement requirement. Basic choices for specialized or general purpose, low frequency measurement applications are: single or dual channel 500 kHz displays, 5 mV/div or 100 μV/div deflection factors, standard or storage CRTs, and a 7 MHz, dual channel, 5 mV/div model—all available in cabinet or rack configurations. In addition, these lightweight instruments allow measurements in remote or difficult access areas such as: aircraft flight lines, communications field sites, or weapons test sites.

The 500 kHz models provide balanced inputs on all ranges and on each channel which is useful in low level audio applications. An additional feature on the dual channel models is an A vs. B mode, which displays channel A signal versus channel B signal through identical amplifiers with less than 1° phase shift up to 100 kHz.

Field effect transistors at the vertical amplifier input provide stable, low-drift operation virtually free of annoying trace shifts caused by temperature changes, shock, and vibration. Long term stability also means less frequent calibration and lower periodic maintenance costs.

Rack versions (designated by a B, "1200B," following the model number) are only 5¼ inches high which saves valuable rack space and allows more instruments to be included in a rack for a more versatile system. Since these instruments are complete oscilloscopes, they offer the system user a read-out device and a convenient calibration and service tool.

In applications with displays that occur at slow rates, a storage/variable persistence CRT is available that will eliminate the annoying flicker or retain single occurrence traces. This longer persistence is useful when displaying slowly moving bio-medical phenomena and applications where the trace or display information must persist after the exitation is removed. Improvements in target material and processing provide a very rugged storage surface. This highly burn resistant storage surface does not require special operating procedures which increases ease-of-use in low frequency applications.

Single, normal, and free run modes of sweep operation are flexible enough for complex measurements, yet operation is simple and straight forward. The sweep time and magnifier controls provide a direct reading of a magnified sweep which reduces the chance of error and time for measurements.

Specification grouping

Due to the similarity of these oscilloscopes, the specifications have been grouped to reduce redundancy and increase usability. The layout is as follows: Cathode-Ray Tube (standard and storage); vertical amplifiers in sequence of 500 kHz, 100 μV/div and 5 mV/div, and 7 MHz, 5 mV/div; Time Base, common to all 1200 oscilloscopes; followed by combined general information.

STANDARD & STORAGE CRT
500 kHz, 100 μV/div
1200 Series

1200 Series Oscilloscope Selection Chart

Feature	1200A/B*	1201A/B*	1202A/B*	1205A/B*	1206A/B*	1217A/B*
Deflection Factor/div	0.1 mV to 20 V	0.1 mV to 20 V	0.1 mV to 20 V	5 mV to 20 V	5 mV to 20 V	5 mV to 20 V
Bandwidth	500 kHz	500 kHz	500 kHz	500 kHz	500 kHz	7 MHz
Number of Traces	2	2	1	2	1	2
Differential Input	all ranges	all ranges	all ranges	all ranges	all ranges	all ranges (B-A)
CMRR	100 dB	100 dB	100 dB	50 dB	50 dB	30 dB
Common-mode Signal Maximum	±10 V	±10 V	±10 V	±3 V	±3 V	30 div
Phase Shift (A vs B)	1° to 100 kHz	1° to 100 kHz	–	1° to 100 kHz	–	–
Sweep Speeds/div	1 μs to 5 s	1 μs to 5 s	1 μs to 5 s	1 μs to 5 s	1 μs to 5 s	1 μs to 5 s
Ext. Horiz. Input	yes	yes	yes	yes	yes	yes
DC-coupled Z-axis	yes	yes	yes	yes	yes	yes
Variable Persistence and storage	no	yes	no	no	no	no
Price	$1050	$1900	$815	$950	$765	$1175

*"A" denotes standard bench model, e.g. 1200A. "B" denotes standard rack model e.g. 1200B.

Specifications, 1200 Series

Cathode-ray tube and controls

Standard CRT

Type: mono-accelerator, 3000 V accelerating potential; P31 phosphor standard (refer to options for other phosphors).

Graticule: 8 x 10 div internal graticule, 0.2 subdivision markings on horizontal and vertical major axes. 1 div = 1 cm.

Beam finder: returns trace to CRT screen regardless of setting of horizontal, vertical, or intensity controls.

Intensity modulation: +2 V signal blanks trace of normal intensity; +8 V signal blanks any intensity trace. DC-coupled rear panel input; amplifier risetime, approx 200 ns; input R, 5 k ohms.

Variable persistence/storage CRT

1201A/B

Type: post-accelerator, variable persistence storage tube; 10.5 k V accelerating potential; aluminized P31 phosphor.

Graticule: 8 x 10 div internal graticule. 0.2 subdivision markings on major axes. 1 div = 0.95 cm. Front panel recessed screwdriver adjustment aligns trace with graticule.

Intensity modulation: +2 volt signal blanks trace of normal intensity. +8 volt signal blanks trace of any intensity. DC-coupled input on rear panel; amplifier risetime approx 200 ns; input R is approx 5 k ohms.

Beam finder: returns trace to CRT screen regardless of horizontal or vertical control settings.

Persistence/storage characteristics

(Referenced to a centered 7 x 9 div area in STD mode and to a centered 6 x 8 div area in FAST mode.)

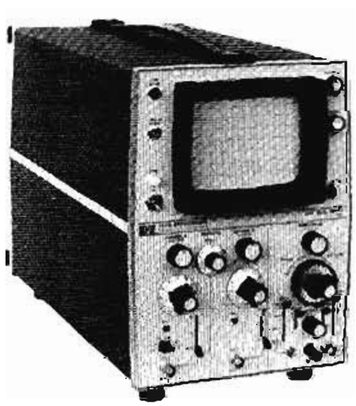
Persistence: conventional, natural persistence of P31 phosphor, approx 40 μs. Variable, continuously variable from 0.2 s to >1 min. in STD mode; and from 0.2 s to 15 s in FAST mode.

Storage writing speed: STD mode, 20 div/ms; FAST mode, 0.5 div/μs.

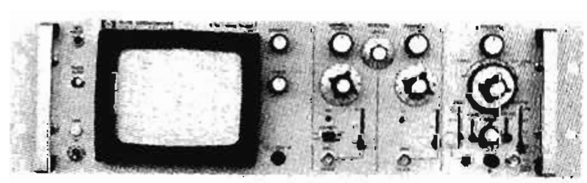
Brightness: 100 foot-lambers in write mode.

Storage time: STD writing speed, variable from approx 1 minute to >2 hours. Fast writing speed, variable from approx 15 s to >15 min.

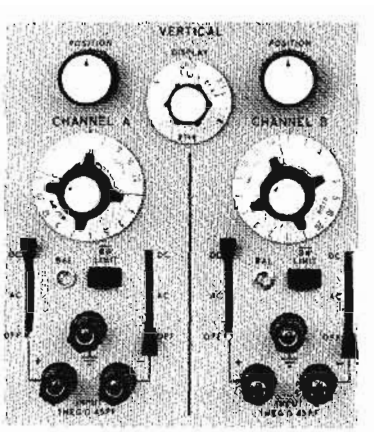
Erase: pushbutton erasure takes approx 1.2 s. Write gun is blanked and sweep is reset until erasure is completed.



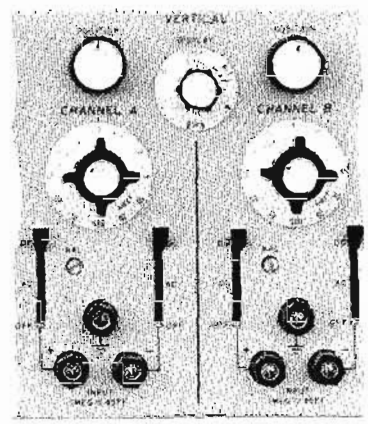
1217A



1217B



1201A/B
Vertical Amplifier



1205A/B
Vertical Amplifier

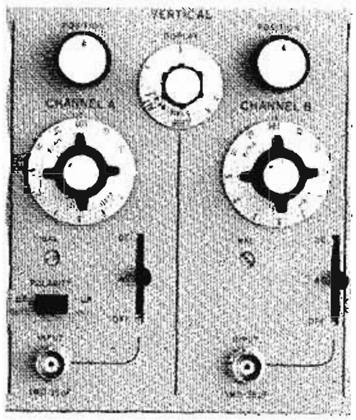
Vertical amplifiers

100 μV, 500 kHz
1200A/B, 1201A/B, 1202A/B

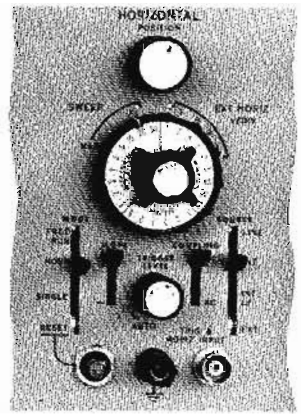
Bandwidth: dc-coupled, dc to 500 kHz; ac-coupled, 2 Hz to 500 kHz.
Bandwidth limit switch: allows selection of upper bandwidth limit to approx 50 kHz or 500 kHz.
Risetime: 0.7 μs max.
Deflection factor
Ranges: from 0.1 mV/div to 20 V/div (17 positions) in 1, 2, 5 sequence.
Attenuator accuracy: ±3% with vernier in calibrated position.
Vernier: continuously variable between all ranges; extends maximum deflection factor to at least 50 V/div.
Noise: <20 μV measured tangentially at full bandwidth.
Input: differential or single-ended on all ranges, selectable.
Common mode
Frequency: dc to 10 kHz on all ranges.
Rejection ratio: 100 dB (100,000 to 1) with dc-coupled input on 0.1 mV/div range, decreasing by <20 dB per decade of deflection factor to at least 40 dB on the 0.2 V/div range; CMRR is at least 30 dB on the 0.5 V/div ranges.
Maximum signal: ±10 V (dc + peak ac) on 0.1 mV/div to 0.2 V/div ranges; ±400 V (dc + peak ac) on all other ranges.
Input coupling: selectable AC, DC, or OFF for both + and − inputs.
Input RC: 1 megohm shunted by approx 45 pF; constant on all ranges.
Maximum input: ±400 V (dc + peak ac).
Remaining vertical amplifier specifications apply only to dual channel models
Modes of operation: Channel A alone; Channel B alone; Channels A and B (either Chop or Alternate); Channels A and B vs. horizontal input (Chop only); Channel A vs. B (A-vertical, B-horizontal). Chop frequency is approx 100 kHz.
Internal trigger source: on Channel A signal for A, Chop, and Alternate displays. On Channel B signal for B display.
Isolation: >80 dB between channels at 500 kHz, with shielded input connectors.
Phase shift: (Channel A vs. B) <1° to 100 kHz with verniers in calibrated position.

5 mV/div, 500 kHz
1205A/B, 1206A/B

Bandwidth: dc-coupled, dc to 500 kHz; ac-coupled, 2 Hz to 500 kHz.
Risetime: 0.7 μs max.
Deflection factor
Ranges: from 5 mV/div to 20 V/div (12 positions) in 1, 2, 5 sequence.
Attenuator accuracy: ±3% with vernier in calibrated position.
Vernier: continuously variable between all ranges; extends maximum deflection factor to at least 50 V/div.
Input: differential or single-ended on all ranges, selectable.
Common mode
Frequency: dc to 10 kHz on all ranges.
Rejection ratio: 50 dB with dc-coupled input on 5 mV/div to 0.2 V/div ranges; CMRR is at least 30 dB on the 0.5 V/div to 20 V/div ranges.
Maximum signal: ±3 V (dc + peak ac) on 5 mV/div to 0.2 V/div ranges; ±300 V (dc + peak ac) on all other ranges.
Input coupling: selectable AC, DC or OFF for both + and − inputs.
Input RC: 1 megohm shunted by approx 45 pF; constant on all ranges.
Maximum input: ±400 V (dc + peak ac).
Remaining vertical amplifier specifications apply only to dual channel models
Modes of operation: Channel A alone; Channel B alone; Channels A and B (either Chop or Alternate); Channels A and B vs. horizontal input (Chop only); Channels A vs. B (A-vertical, B-horizontal). Chop frequency is approx 100 kHz.
Internal trigger source: on Channel A signal for A, Chop, and Alternate displays. On Channel B signal for B display.
Isolation: >80 dB between channels at 500 kHz, with shielded input connectors.
Phase shift: (Channel A vs. B) <1° to 100 kHz with verniers in calibrated position.



1217A/B
Vertical Amplifier



Typical Horizontal
Time Base

5 mV/div, 7 MHz
1217A/B

Bandwidth: dc-coupled, dc to 7 MHz; ac-coupled, 2 Hz to 7 MHz.
Risetime: 50 ns max.
Deflection factor
Ranges: from 5 mV/div to 20 V/div (12 positions) in 1, 2, 5 sequence.
Attenuator accuracy: ±3% with vernier in calibrated position.
Vernier: continuously variable between all ranges; extends maximum deflection factor to at least 50 V/div.
Input RC: 1 megohm shunted by approx 35 pF; constant on all ranges.
Input: single-ended on all ranges.
Input coupling: selectable AC, DC, or OFF.
Modes of operation: Channel A alone; Channel B alone; Channels A and B (either Chop or Alternate triggered by Channel A); Channels A + B (triggered by Channels A + B). Chop frequency is approx 100 kHz.
Differential input: Channel A may be inverted for differential operation. Bandwidth and deflection factors remain unchanged.
Common mode
Frequency: dc to 100 kHz.
Rejection ratio: 30 dB on 5, 10, and 20 mV/div ranges and 20 dB on all other ranges.
Maximum signal: 30 div.
Internal trigger source: on Channel A signal for A, Chop, and Alternate displays; on Channel B signal for B display; on Channels A + B signal for Channel A + B display.

Time Base

All models
Sweep
Ranges: from 1 μs/div to 5 s/div (21 positions) in 1, 2, 5 sequence, ±3% accuracy with vernier in calibrated position.
Vernier: continuously variable between ranges; extends slowest sweep to at least 12.5 s/div.
Magnifier: direct reading x10 magnifier expands fastest sweep to 100 ns/div with ±5% accuracy.
Automatic triggering
Baseline is displayed in absence of an input signal.
Internal: 50 Hz to above 500 kHz (2 MHz in 1217A/B) on most signals causing 0.5 division or more vertical deflection, increasing to 1 div at 7 MHz in Models 1217A/B. Triggering on line frequency also selectable.
External: 50 Hz to above 1 MHz (2 MHz in 1217A/B) on most signals at least 0.2 V p-p, increasing to 0.5 V p-p at 7 MHz in Models 1217A/B.
Trigger slope: positive or negative slope on internal, external, or line trigger signals.
Amplitude selection triggering
Internal: dc to above 500 kHz on signals causing 0.5 division or more vertical deflection.
External: dc to 1 MHz on signals at least 0.2 V p-p. Input impedance is 1 megohm shunted by approx 20 pF.
Trigger level and slope: internal, at any point on vertical waveform displayed; or continuously variable from +100 V to −100 V on either slope of the external trigger signal.
Trigger coupling: dc or ac for external, line, or internal triggering. Lower ac cutoff is 2 Hz for external; 5 Hz for internal.
Internal low frequency triggering (1217A/B only): internal trigger signal is attenuated at approx 6 dB per octave for frequencies above 5 MHz.
Single sweep: selectable by front panel switch. Reset switch with armed indicator light.
Free run: selectable by front panel switch.
Maximum input: ±350 V (dc + peak ac).
Horizontal amplifier
Bandwidth: dc-coupled, dc to 300 kHz; ac-coupled, 2 Hz to 300 kHz.
Deflection factor
Ranges: 0.1 V/div, 0.2 V/div, 0.5 V/div, and 1 V/div.
Vernier: continuously variable between ranges; extends maximum deflection factor to at least 2.5 V/div.
Maximum input: ±350 V (dc + peak ac).
Input RC: 1 megohm shunted by approx 20 pF.
Input: single-ended on all ranges.

FLEXIBLE SWEEP & TRIGGER
Direct reading magnifier
1200 Series

General

Calibrator

Type: line frequency square wave.
Output: 1 V ±1.5%.

Dimensions

Cabinet models (designed by A suffix): 8-5/16" wide x 11¾" high x 8-11/16" deep (211, 2 x 298, 5 x 474,7 mm).
Rack models (designated by B suffix): 19" wide x 5¼" high x 17⅛" deep over-all (483 x 132, 5 x 435 mm), 15⅜" (390,5 mm) behind front panel.

Power: 115 or 230 V ±10%, 48 to 440 Hz, approximate watts 1200A/B, 50 W; 1201A/B, 60 W; 1202A/B, 40 W; 1205A/B, 45 W; 1206A/B, 40 W; 1217A/B, 75 W.

Weight

1200A: net, 25 lbs (11,4 kg); shipping, 34½ lbs (15,7 kg).
1200B: net, 22½ lbs (10,2 kg); shipping, 35 lbs (15,9 kg).
1201A: net, 30 lbs (13,6 kg); shipping, 39½ lb (17,9 kg).
1201B: net, 27½ lbs (12,5 kg); shipping, 40 lbs (18,2 kg).
1202A: net, 23½ lbs (10,6 kg); shipping, 33 lbs (15 kg).
1202B: net, 21 lbs (9,5 kg); shipping, 33½ lbs (15,2 kg).
1205A: net, 25 lbs (11,4 kg); shipping, 34½ lbs (15,7 kg).
1205B: net, 22½ lbs (10,2 kg); shipping, 35 lbs (15,9 kg).
1206A: net, 23½ lbs (10,6 kg); shipping, 33 lbs (15 kg).
1206B: net, 21 lbs (9,5 kg); shipping, 33½ lbs (15,2 kg).
1217A: net, 24½ lbs (11,1 kg); shipping, 34½ lbs (15,7 kg).
1217B: net, 23 lbs (10,4 kg); shipping, 35 lbs (15,9 kg).

Price

Model 1200A or 1200B Dual Channel, 100 μV Oscilloscope	$1050
Model 1201A or 1201B Dual Channel, 100 μV Storage Oscilloscope	$1900
Model 1202A or 1202B Single Channel, 100 μV Oscilloscope	$ 815
Model 1205A or 1205B Dual Channel, 5 mV Oscilloscope	$ 950
Model 1206A or 1206B Single Channel, 5 mV Oscilloscope	$ 765
Model 1217A or 1217B Dual Channel, 5 mV, 7 MHz Oscilloscope	$1175

Options (order by Option number)

002 (standard CRT only): P2 phosphor in lieu of P31, no charge.

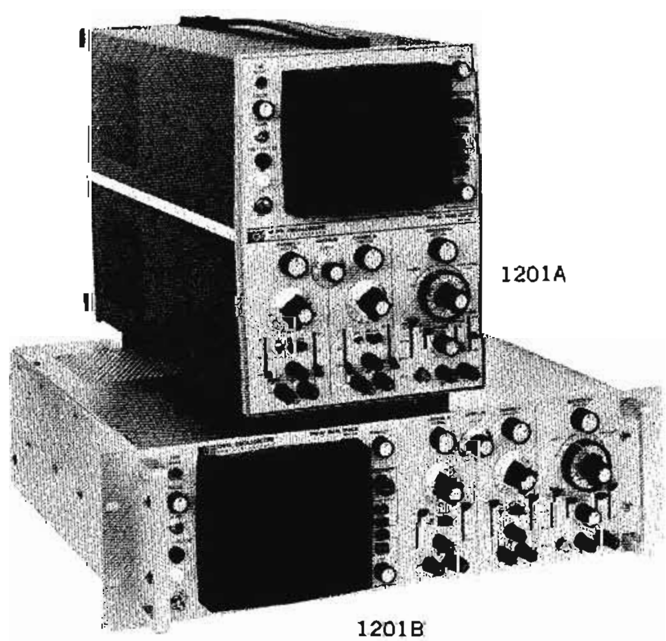
006 (rack models only): rear input terminals wired in parallel with front panel vertical and horizontal input terminals. Vertical input shunt capacitance is increased to approx 100 pF on 500 kHz models and to approx 85 pF on 7 MHz models. Horizontal input shunt capacitance is increased to approx 75 pF on 500 kHz and 7 MHz models.
Price: add $35 for single channel models and $55 for dual channel models.

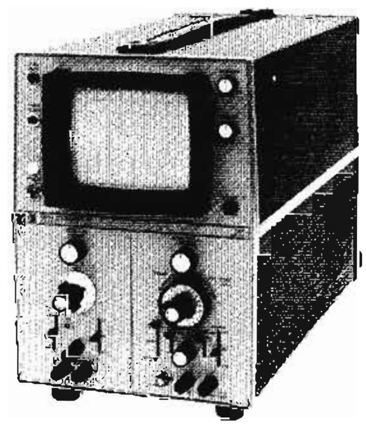
007 (standard CRT only): P7 phosphor in lieu of P31, no charge.

009 (variable persistence/storage models only): remote erase through rear panel banana jack, shorting to ground provides erasure, add $25.

011 (standard CRT only): P11 phosphor in lieu of P31, no charge.
Beamfinder does not intensify display on Option 011 Oscilloscopes.

015 (500 kHz models only): vertical channel signal outputs through rear panel connectors.
Vertical output signal specifications
Output: 0.3 V/div ±10%, 0 V offset unaffected by position control setting.
Bandwidth: dc to 500 kHz.
Dynamic range: ±3.5 V.
Maximum slewing rate: 12 V/μs with 300 pF load.
Minimum load RC: 10 k ohms shunted by approx 300 pF.
Source impedance: approx 300 ohms.
Price: single channel models, add $70; dual channel models, add $95.

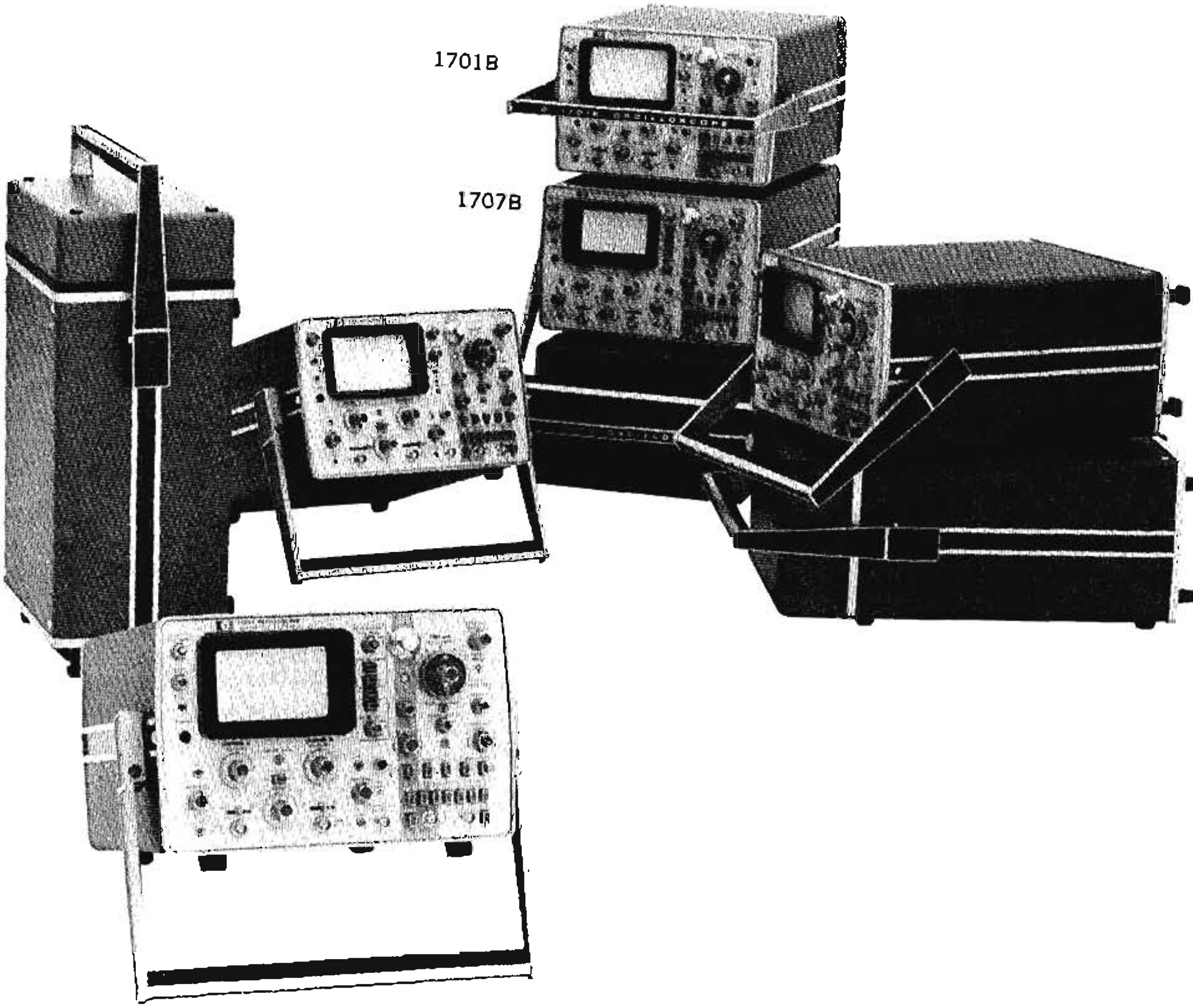

1201A
1201B


1206A

PORTABLE 35, 75, and 150 MHz

AC, dc, or battery operation, 10 and 5 mV/div

1700 Series



1700 Series

Introduction

Hewlett-Packard 1700 Series oscilloscopes are compact, light weight, portable instruments designed for field service applications with laboratory quality. All models are dual channel with a selection of 35, 75, or 150 MHz bandwidths which allows you to match a scope to a particular application. You can select models having main and delayed time bases for maximum timing flexibility. For applications at 35 or 75 MHz, scopes are available with only the main time base. The 1700 series also includes three models with highly burn resistance storage and variable persistence capability and one of these models has a fast storage writing speed of 100 cm/μs.

Operator convenience

All 1700 Series oscilloscopes have large CRT's with sharp traces for easy viewing and high resolution for accurate measurements. Standard CRT displays are fully calibrated 6 x 10 cm; variable persistence/storage displays are slightly smaller. Front panel controls are grouped according to function for fast familiarization and pushbuttons are used to further simplify operation. By centering all front panel controls and releasing all pushbuttons, you can easily locate a trace for fast setup in viewing a waveform. Delayed sweep models have the delayed sweep controls in a gray front panel strip for quick identification.

Main and delayed sweep speeds are selected with separate controls which allows you to change the sweep on one time base without having to reset the other. An interlock is provided to prevent the delayed time base from sweeping slower than the main time base.

Another convenience feature, on conventional CRT models, is scale illumination which aids in photographic work. A convenient beam finder, introduced by Hewlett-Packard, allows quick location of the trace by restricting the beam to the display area. Indicator lights are provided to show when the vertical deflection and sweep controls are not in the calibrated (detent) position. Additional conveniences are front panel ad-

PORTABLE 35, 75, and 150 MHz
10 ns/div sweep speeds, standard/delayed sweeps
1700 Series

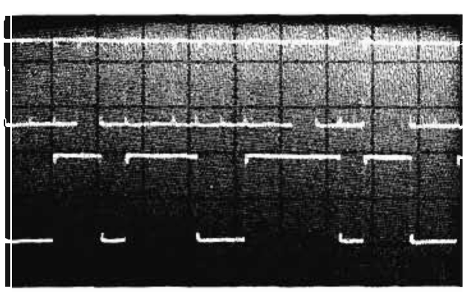
justments for vertical deflection calibration, dc balance, and a one volt square wave calibration signal for probe compensation.

Performance

The 1700 Series—though light-weight, rugged, and portable—gives you the performance ordinarily expected of laboratory oscilloscopes. Vertical deflection is specified over the full six divisions of vertical display, as indicated by the 10% and 90% CRT graticule markings. Similarly, all deflection factors are specified over the entire bandwidth. In addition, display mode and trigger source selection assures you of the right trigger signal for your application.

Emphasis on performance is also provided in the 1700 Series time base. Sweep linearity is specified over the full 10 divisions of horizontal display for maximum usefulness and accuracy in timing measurements. A trigger holdoff control, also introduced by Hewlett-Packard, is provided to eliminate double triggering on complex digital waveforms and maintain a full-screen, calibrated sweep. In delayed sweep models, you can make differential timing measurements to approximately 1% accuracy by using a common reference graticule.

Calibrated mixed sweep is standard on all 1700 Series delayed sweep models. The calibration point is at the beginning of the intensified portion of the main sweep and corresponds to the delay dial setting. Mixed sweep is useful for detailed examination of individual pulses in a pulse train by allowing you to "peel" them off one at a time. It is also useful when you want to monitor events prior to the occurrence of the pulse under close examination.



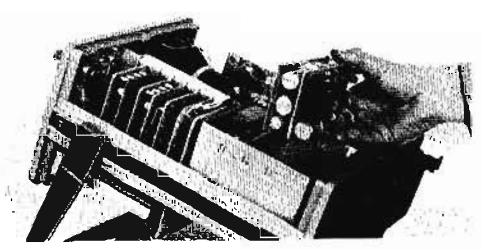
Double exposure shows how stable triggering on a digital word is obtained with the *TRIGGER HOLDOFF* control. The stable sweep remains full screen and calibrated.

Reliability

1700 Series oscilloscopes have been designed for low power consumption which increases reliability since most active components operate at only 10 to 20% of their power rating. An example of the low power is that the vertical output transistors do not require heat sinks. The low power requirement also means that the 1700 Series oscilloscopes do not require ventilating holes or fans for cooling which reduces the amount of dust and dirt that can accumulate inside the scope. The lack of ventilation holes also reduces dc drift since the scope is less susceptible to short term temperature changes caused by drafts. Reliability in the trigger circuits is enhanced by emitter-coupled logic circuits instead of conventional tunnel diodes.

Serviceability

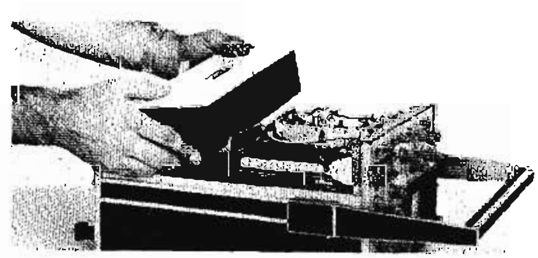
Ease of service is assured with plug-in circuit boards and the low number of internal adjustments. For example, if all adjustments were misaligned, a technician (with a working knowledge of the scope) could completely recalibrate a 1700B in as little as one hour. This means real dollar savings over the lifetime of the oscilloscope.



Plug-in printed circuit boards reduce service time. When added to low calibration time, this means significant dollar savings over the lifetime of the instrument.

Battery operation

Seven portable oscilloscopes (Models 1700B, 1701B, 1702A, 1703A, 1705A, 1706B, and 1707B) are capable of battery operation. The optional, internal battery is easily installed with just two screws and does not require any power supply changes. Battery operation allows operation in remote locations without regard for line power connections and are also well suited for many maintenance and check out applications, especially where line isolation is required. Battery operation can often save time on a service call, since you can move the scope around without having to turn off power, move and find a new outlet, turn-on, restabilize, and recalibrate the display.



The optional battery is easily installed and operates the scope up to 6 hours (1700B/1701B).

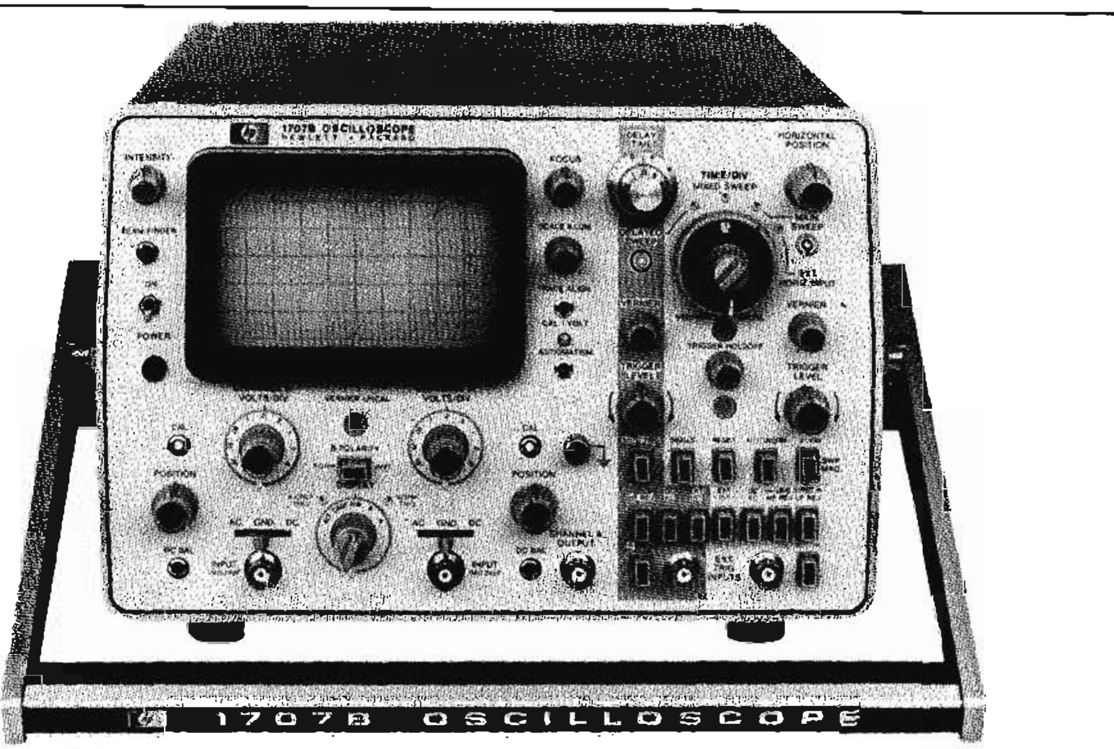
Ruggedized portables

Hewlett-Packard model 1700B and 1707B have been designed to meet the environmental requirements of the AN/USM-339 and AN/USM-338 described in MIL-0-83226 (USAF) and MIL-0-83225 (USAF). These ruggedized oscilloscopes, designated 1700B Option 300 and 1707B Option 300, not only maintain the fully calibrated features of the 1700B/1707B but go far beyond the environmental capabilities of other portable instruments. For example, they will pass the drip-proof requirements of MIL-STD-108 with the front panel cover removed.

PORTABLE, 35 AND 75 MHz

Dual channel, 10mV/div

Models 1700B, 1701B, 1706B, 1707B



1707B

General information about Hewlett-Packard's portable oscilloscopes begins on page 156.

Specifications, 1700B, 1701B, 1706B, 1707B

Vertical amplifiers

Modes of operation: channel A; channel B; channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at approx 400 kHz rate with blanking during switching (Chop); channel A + channel B (algebraic addition).

Each channel (2)

Bandwidth: (Direct or with Model 10006B probe, 3 dB down from 50 kHz, 6 div reference signal from a terminated 50 ohm source.) dc-coupled, dc to 35 MHz in 1700B, 1701B; dc to 75 MHz in 1706B, 1707B; ac-coupled, lower limit is approx 10 Hz.

Risetime: <10 ns in 1700B, 1701B; <4.7 ns in 1706B, 1707B. Direct or with Model 10006B probe, 10% to 90% points with 6 div input step from a terminated 50 ohm source.

Deflection factor

Ranges: from 10 mV/div to 5 V/div (9 ranges) in 1,2,5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between all ranges, extends maximum deflection factor to at least 12.5 V/div.

Polarity: NORM or INV, selectable on channel B.

Signal delay: input signals are delayed sufficiently to view leading edge of input signals without advanced external trigger.

Input RC

1700B, 1701B: 1 megohm ±1%, shunted by approx 27 pF.

1706B, 1707B: 1 megohm ±1%, shunted by approx 24 pF.

Input coupling: AC, DC, or Ground selectable. Ground position disconnects signal input and grounds amplifier input.

Maximum input

AC-coupled: ±600 V(dc + peak ac); rms ac <350 V, 5V/div to 20 mV/div; <150 V at 10 mV/div (10 kHz or less).

DC-coupled: <350 V (rms) 5 V/div to 20 mV/div; <150 V at 10 mV/div (10 kHz or less).

A + B operation

Amplifier: bandwidth and deflection factors are unchanged; channel B may be inverted for A-B operation.

Common mode (A-B): frequency, dc to 1 MHz; rejection ratio, at least 40 dB on 10 mV/div, at least 20 dB on all other ranges with verniers set for optimum rejection. Common mode signal amplitude equivalent to 30 div.

Trigger source

(applies for all five modes of operation)

Norm: on displayed signal.

A only: on signal from Channel A.

Time base

Sweep

Ranges: from 0.1 μs/div to 2 s/div (23 ranges) in 1,2,5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between all ranges, extends slowest sweep to at least 5 s/div. Vernier uncalibrated light indicates when vernier is not in Cal position.

Magnifier: expands all sweeps by a factor of 10 and extends fastest sweep to 10 ns/div. Accuracy ±5% (including 3% accuracy of time base.)

Sweep mode

Normal: sweep is triggered by internal or external signal.

Automatic: bright baseline displayed in absence of input signal. Triggering is same as normal above 40 Hz.

Single: in Normal mode, sweep occurs once with same triggering as normal; reset pushbutton arms sweep and lights indicator; in Auto mode, sweep occurs once each time Reset pushbutton is pressed.

Triggering

Internal

1700B, 1701B: dc to 35 MHz on signals causing 0.5 div or more vertical deflection increasing to 1.5 div at 75 MHz in all display modes except chop; dc to 400 kHz in chop mode. Triggering on line frequency is also selectable.

1706B and 1707B: dc to 35 MHz on signals causing 0.5 div or more vertical deflection increasing to 1 div at 75 MHz in

PORTABLE, 35 AND 75 MHz
Delayed, non-delayed sweeps
Models 1700B, 1701B, 1706B, 1707B

all display modes except chop; dc to 400 kHz in chop mode. Triggering on line frequency is also selectable.

External: dc to 35 MHz on signals 50 mV p-p or more, increasing to 100 mV p-p at 75 MHz.

External input RC: approx 1 megohm shunted by approx 27 pF.

Level and slope: internal, at any point on the vertical waveform displayed; external, continuously variable from +1.2 V to −1.2 V on either slope of the trigger signal. Maximum input, ±100 V. In Models 1700B and 1706B, ÷10 extends external trigger input range to +12 V to −12 V.

Coupling: AC, DC, LF REJ, or HF REJ.
- **AC:** attenuates signals below approx 20 Hz.
- **LF-REJ:** attenuates signals below approx 15 kHz.
- **HF-REJ:** attenuates signals above approx 30 kHz.

Trigger holdoff: time between sweeps continuously variable.

Delayed time base (Models 1701B and 1707B)

Trace intensification: intensifies that part of main time base to be expanded to full screen in delayed time base mode. Rotating time base switch from OFF position activates intensified mode.

Sweep
- **Ranges:** 0.1 μs/div to 0.2 s/div (20 ranges) in 1,2,5 sequence. ±3% with vernier in calibrated position.
- **Vernier:** continuously variable between all ranges, extends slowest sweep to 0.5 s/div.
- **Magnifier:** expands all sweeps by a factor of 10 and extends fastest sweep to 10 ns/div. Accuracy is ±5% (including 3% accuracy of time base).

Sweep Mode
- **Trigger:** delayed sweep is armed at end of delay period.
- **Auto:** delayed sweep is automatically triggered at end of delay period.

Triggering
- **Internal:** same as main time base.
- **External:** same as main time base. Input RC is approx 1 megohm shunted by approx 27 pF.
- **Level and slope:** internal, at any point on the vertical waveform displayed; external, continuously variable from +1.2 V to −1.2 V on either slope of the trigger signal.
- **Coupling:** selectable, AC or DC. AC attenuates signals below approx 20 Hz.

Delay (Before start of delayed sweep.)
- **Time:** continuously variable from 0.1 μs to 2 s.
- **Time Jitter:** <0.005% (1 part in 20,000) of maximum delay in each sweep.
- **Calibrated delay accuracy:** ±1%; linearity, ±0.2%.

Mixed Sweep (Models 1701B and 1707B): combines main and delayed sweeps into one display. Sweep is started by the main time base and is completed by the faster delayed time base.

Cathode-ray tube and controls

Type: post-accelerator, ≈22 kV accelerating potential, aluminized P31 phosphor.

Graticule: 6 x 10 div internal graticule; 0.2 subdivisions on major horizontal and vertical major axes. 1 div = 1 cm. Front panel adjustments for trace alignment and astigmatism.

Beam finder: returns trace to CRT screen regardless of setting of horizontal, vertical, or intensity controls.

Intensity modulation: >+4 V, dc to 1 MHz blanks trace of any intensity. Input R, 1000 ohms ±10%. Max input, ±10 V (dc + peak ac).

General

Calibrator: 1 kHz, ±10%; 1 V p-p, ±1%.

Power requirements
- **AC line:** 115 or 230 V ±20%, 48 to 440 Hz; 1700B, 1701B, 30 VA max; 1706B, 1707B, 50 VA max.
- **DC line:** 11.5 to 36 V; 1700B, 1701B, 18 watts max; 1706B, 1707B, 25 watts max.

Battery (optional)

Operating time: up to 6 hours in 1700B or 1701B; up to 4.5 hours in 1706B or 1707B.

Recharge time: 14 hours maximum, with power switch off, if not operated after power indicator flashes.

Low battery indicator: power light flashes to indicate that batteries are discharged and further operation may damage battery.

Recharging: batteries are recharging whenever power mode switch is set to AC with power applied. With power switch off, full charge is applied. With power switch on, trickle charge is applied.

Weight
- **Without panel cover:** net, 24 lb (11 kg); shipping, 35 lb (15,9 kg).
- **With panel cover and accessories:** net, 27 lb (12,3 kg); shipping, 38 lb (17,2 kg).
- **With panel covers, accessories, and battery pack:** net, 35 lb (16 kg); shipping, 46 lb (20,9 kg).

Dimensions: 12-13/16" wide, 7¾" high, 20⅞" long with handle, 15⅜" without handle (325,4 x 198 x 530, 400 mm).

Operating environment: temperature 0°C to +55°C; humidity, to 95% relative humidity to 40°C, altitude, to 15,000 ft; vibration, vibrated in three planes for 15 min, each with 0.010 inch excursion, 10 to 55 Hz.

Accessories furnished: one Model 10115A blue light filter; one Model 10101B front panel storage cover; two Model 10006B, 10:1 divider probes, 6 ft (1,8 m) long; one 7.5 ft (2,3 m) power cord with right angle plug (HP P/N 8120-1521); and one Operating and Service manual.

Price

Model 1700B 35 MHz Oscilloscope	$1475
Model 1701B 35 MHz Delayed Sweep Oscilloscope	$1550
Model 1706B 75 MHz Oscilloscope	$1500
Model 1707B 75 MHz Delayed Sweep Oscilloscope	$1575

Options

012: Model 10103B battery pack installed	add $ 215
020 (1707B): adds external horizontal input and channel A output	add $ 50

1707B Option 020 specifications

External horizontal input
- **Bandwidth:** dc to 1 MHz when driven directly from a terminated 50 ohm source.
- **Coupling:** dc
- **Deflection factor (with beam positioned at left edge of CRT):** X1, 1 V/div; X10, 0.1 V/div.
- **Vernier:** 10:1 vernier extends deflection factor to at least 10 V/div (X1) or 1 V/div (X10).
- **Dynamic range:** beam may be positioned at left edge of CRT with 0 V to −5 V input.
- **Maximum input:** ±100 V.
- **Input RC:** 1 megohm shunted by approx 10 pF.

Channel A output
- **Amplitude:** one division of displayed signal in channel A produces approx 100 mV output.
- **Cascaded deflection factor:** 1 mV/div with both vertical channels set to 10 mV/div.
- **Cascaded bandwidth:** dc to 3 MHz. Use supplied HP Model 10121A 8-inch (20 cm) BNC cable.
- **Coupling:** dc.
- **Vertical output dc level:** approx 0 V.
- **Vertical output resistance:** approx 0 V.

RUGGEDIZED PORTABLE
35 and 50 MHz, dual channel
Models 1700B Opt 300, 1707B Opt 300

1700B Option 300

General information about Hewlett-Packard's portable oscilloscopes begins on page 156.

Specifications

Modes of operation: channel A; channel B; channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at approximately 100 kHz rate with blanking during switching (CHOP); channel A + channel B (algebraic addition).

Each vertical amplifier channel (2)

Bandwidth: direct or with Model 10006B probe, 3 dB down from 50 x 20 kHz, 6 div reference signal from a terminated 50 ohm source.
- **DC-coupled:** 1700B, dc to 35 MHz; 1707B, dc to 50 MHz.
- **AC-coupled:** 1700B, approx 10 Hz to 35 MHz; 1707B, approx 2 Hz to 50 MHz.

Risetime: 1700B, <10 ns; 1707B, <7 ns. Direct or with Model 10006B probe, 10% to 90% points of 6 div input step from a terminated 50 ohm source.

Deflection factor
- **Ranges:** 1700B, 10 mV/div to 20 V/div (11 ranges); 1707B, 5 mV/div to 20 V/div (12 ranges). 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated setting.
- **Vernier:** continuously variable between all ranges, extends maximum deflection factor to at least 50 V/div.
- **Signal delay:** input signals are delayed sufficiently to view leading edge of input signals without advanced external trigger.
- **Polarity:** NORM or INV, selectable on channel B.

Input: 1 megohm ±2%, shunted by approx 35 pF (1700B), 30 pF (1707B).

Input coupling: ac, dc, or ground selectable. Ground position disconnects input and grounds amplifier input.

Maximum input:
- **AC-coupled:** ±600 V max (dc + peak ac); <350 V rms, 20 V/div to 20 mV/div; <150 V rms, at 10 mV/div (1700B) 5 mV/div (1707B) 10 kHz or less.
- **DC-coupled:** <350 V rms 20 V/div to 20 mV/div; < 150 V rms at 10 mV/div (1700B) 10 kHz or less.

A + B operation

Amplifier: bandwidth and deflection factors are unchanged; channel B may be inverted for A-B operation.

Common mode (A-B)
- **Frequency:** dc to 1 MHz (1700B); dc to 3 MHz (1707B).
- **Rejection ratio:** at least 26 dB on all ranges with verniers set for optimum rejection.

Channel A output (1707B)

Amplitude: one div of displayed signal in channel A provides approx 100 mV output.

Cascaded deflection factor: 0.5 mV/div with both vertical channels set to 5 mV/div.

Cascaded bandwidth: dc to 5 MHz with 8-in. BNC cable, dc-coupled.

Output dc level: approx 0 V.

Output resistance: approx 1 megohm.

Triggering

Source (applies for all five modes of operation).
- **Composite trig:** on displayed signal.
- **A trig:** on signal from channel A.

Time base

Sweep
- **Ranges:** from 0.1 μs/div to 2 s/div (23 ranges) in 1, 2, 5, sequence, ±3% accuracy with vernier in calibrated position.
- **Vernier:** continuously variable between all ranges, extends slowest sweep to at least 5 s/div. Vernier uncalibrated light indicates when vernier is not in CAL position.
- **Magnifier:** expands all sweeps by a factor of 10 and extends fastest sweep to 10 ns/div. Accuracy, ±5%. Magnifier light indicates the X10 mode.

Maximum input: ac-coupled: ±600 V max (dc + pk ac).
AC- or dc-coupled: <350 V rms, 20 V/div to 20 mV/div ranges, <150 V rms at ≤10 kHz on more sensitive ranges.

Sweep mode
Normal: sweep is triggered by an internal or external signal.
Automatic: bright base line displayed in absence of input signal. Triggering is same as normal above 40 Hz.
Single: in normal mode, sweep occurs once with same triggering as normal; reset pushbutton arms sweep and lights indicator; in Auto mode, sweep occurs once each time reset pushbutton is pressed.

Triggering
Internal: (1700B) dc to 35 MHz on signals causing 0.5 div or more vertical deflection increasing to 1.5 div deflection at 75 MHz; (1707B) dc to 50 MHz on signals causing 0.5 div or more vertical deflection in all display modes except chop; dc to 100 kHz in chop mode. Triggering on line frequency is also selectable.
External: (1700B) dc to 35 MHz on signals of 50 mV p-p or more, increasing to 100 mV p-p at 75 MHz; (1707B) dc to 35 MHz on signals of 100 mV p-p or more increasing to 200 mV p-p at 50 MHz.
External trigger input RC: 1 megohm shunted by approx 27 pF.

Level and slope
Internal: at any point on the vertical waveform displayed.
External: continuously variable from +3 V to −3 V (+30 V to −30 V in ÷ 10) on either slope of the trigger signal. Maximum input ±100 V.
Coupling: AC, DC, LFAC, or HFAC.
AC: attenuates signals below approx 20 Hz (1700B), 50 Hz (1707B).
LFAC: attenuates signals above approx 30 kHz.
HFAC: attenuates signals below approx 15 kHz (1700B), 5 kHz (1707B).
Trigger holdoff: time between sweeps continuously variable.

Delayed time base (Model 1707B)

Trace intensification: intensifies that part of main time base to be expanded to full screen in delayed time base mode. Rotating time base switch from OFF position activates intensified mode.

Sweep
Ranges: 0.1 μs/div to 0.2 s/div (20 ranges) in 1, 2, 5 sequence. ±3% with vernier in calibrated position.
Vernier: continuously variable between all ranges, extends slowest sweep to 0.5 s/div.
Magnifier: expands all sweeps by a factor of 10 and extends fastest sweep to 10 ns/div. Accuracy is +5% (including 3% accuracy of time base).

Sweep mode
Trigger: delayed sweep is armed at end of delay period.
Auto: delayed sweep is automatically triggered at the end of delay period.
Triggering: same as internal main time base. Delay (before start of delayed sweep).
Time: continuously variable from 0.1 μs to 20 s.
Time jitter: 0.005% (1 part in 20,000) of max delay in each sweep.
Calibrated delay accuracy: ±1%; linearity, ±0.2%.

External horizontal input

Bandwidth: dc to 2 MHz.
Coupling: dc.
Deflection factor (beam positioned at left edge of CRT): **X1:** 1 V/div, **X10,** 0.1 V/div.
Vernier: 10:1 vernier provides continuous adjustment between ranges.
Maximum input: ±100 V.
Input RC: 1 megohm ±2% shunted by approximately 30 pF.

Cathode-ray tube controls

Type: post-accelerator, ≈ 15 kV accelerating potential; aluminized P31 phosphor.
Graticule: 6 x 10 div internal graticule; 0.2 subdivisions on major horizontal and vertical axes. I div = 1 cm. Front panel adjustment aligns trace with graticule.
Beam finder: returns trace to CRT screen regardless of setting of horizontal, vertical, or intensity controls.

Z-axis input (1707B): allows intensity modulation. >5 V, dc to 15 MHz blanks trace of any intensity. Input R, >5000 ohms. Maximum input, ±200 V (dc + peak ac).

General

Calibrator: 1 kHz, ±10% square wave; 1 V p-p, ±1%.
1707B outputs: two front panel outputs for MAIN and DELAYED GATES. Each output provides a pulse of at least 5 V with a duration ≥ than sweep time.

Power requirements
AC line: 115 or 230 V ±20%, 48 to 440 Hz, 30 VA max in 1700B and 50 VA max in 1707B.
DC line: 11.5 to 36 V, 18 watts max in 1700B and 40 watts max in 1707B.

Weight
Without panel cover: net, 27 lb (12,3 kg).
With panel cover and accessories: net, 35 lb (16 kg).
With panel cover, accessories, and battery pack: net, 42 lb (23,7 kg).

Accessory package

An accessory package, supplied with each oscilloscope contains the following: 2ea Model 10006B probes; 2ea probe ground leads (10004-61307); 2ea hook tip assemblies (10004-67604); 2ea banana plugs (1251-0013); 2ea 6/32 probe adapter tips (5060-0449); 2ea spring tip assembles (5060-0420); 2ea BNC tees, plug to 2 jacks, (UG-274C/U); 2ea BNC plug to VHF jack adapters (UG-255/U); 2ea BNC jack to VHF plug adapters (UG-273/U); 1ea BNC plug to dual binding post (UG-1035( )/U); 3ea fuses, one 0.3A slow-blow (2110-0044), one 0.6A slow blow ,2110-0016), and one 2A (2110-0002).

Price
Model 1700B Option 300 — $2395
Model 1707B Option 300 — $2895
Model 1700B Option 300 or 1707B Option 300 with battery Option C12 — add $ 215

Option: Option 301, 1700B Opt 300 or 1707B Opt 30 without Mil nomenclature, no charge.

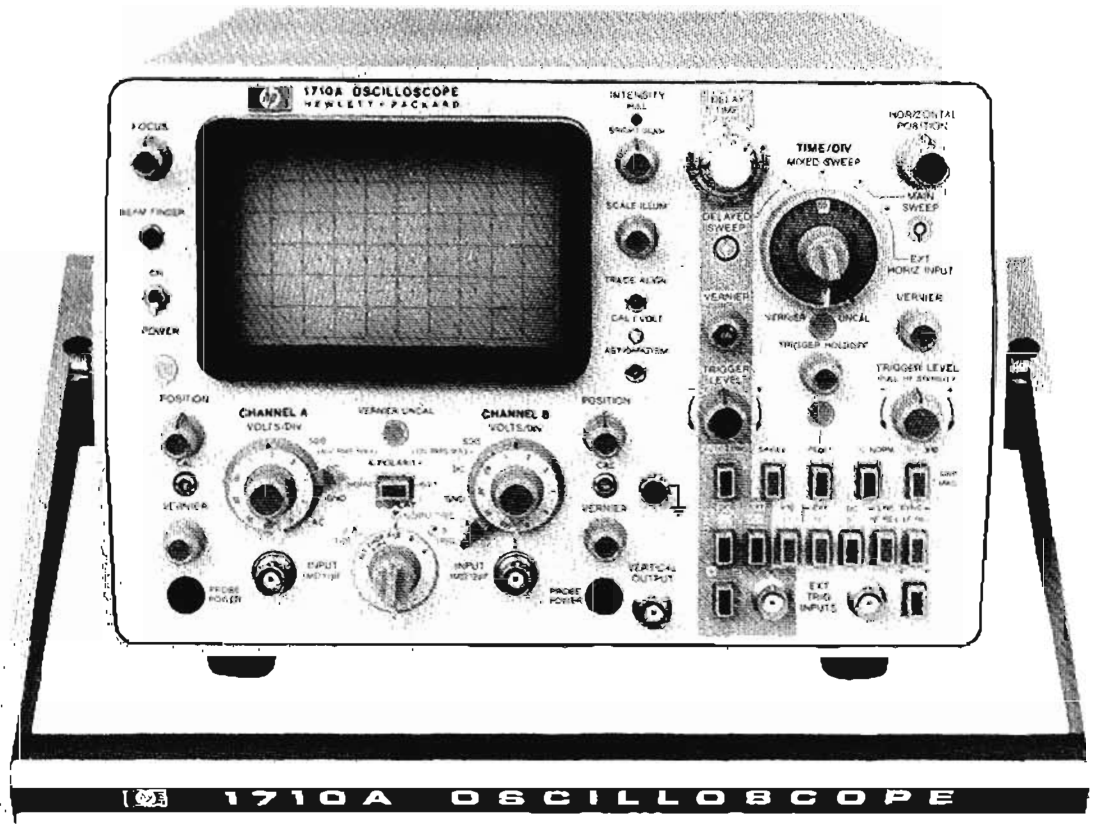
Environmental specifications
1700B Opt 300 and 1707B Opt 300 meet all environmental requirements of the AN/USM-339 described in MIL-0-83226 (USAF) and AN/USM-338 described in MIL-0-83225 (USAF).
Temperature-altitude: non-operating −62 to +85°C, 50,000 feet; operating −40 to +55°C, 20 minutes at 71°C, 10,000 feet.
Humidity: non-operating +28°C to +71°C at 95% relative humidity, ten 24 hour cycles for total of 240 hours.
Vibration: non-operating, 5 to 15 Hz, 0.06 inches; 15 to 25 Hz, 0.04 inches; 25 to 55 Hz, 0.02 inches.
Shock: total of 18 shocks, in 3 planes, of 15 g's from an 11 ±1 ms sawtooth.
Salt fog: non-operating, per method 509, procedure 1 of MIL-STD-810.
Explosive atmosphere: per method 511, procedure 1 of MIL-STD-810.
Dust: non-operating per method 510 procedure 1 of MIL-STD-810.
Dripproof: per MIL-STD-108, except the front panel cover shall be removed.
Drop test and watertightness: per MIL-T-21200.
Electromagnetic interference: per MIL-STD-462 performed by MIL-STD-461 as follows:

Requirement	Limit modification
CE03	relax 10 dB
CS01, CS02	none
CS06	none
RE02	relax 10 dB, upper frequency 1 GHz
RS02, RS04	none

Battery pack parameters in Opt C12

Operating time: up to 6 hours (1700B); up to 4 hours (1707B).
Recharge time: 14 hours maximum, with power switch off, if not operated after power light flashes.
Low battery indicator: power light flashes to indicate that batteries are discharged.
Recharging: batteries are recharging whenever power mode switch is set to AC with power applied. With power switch off, full charge is applied. With power switch on, trickle charge is applied.

PORTABLE, 150 MHz
Dual channel, 5 mV/div
Model 1710A



1710A

- Selectable 50Ω or 1 MΩ input
- Fully calibrated 6 x 10 cm CRT
- Bright scan mode for extra brightness
- Enhanced hf trigger sensitivity

Specifications

Vertical amplifiers

Modes of operation: channel A; channel B; channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at approx 1 MHz rate with blanking during switching (CHOP); channel A + channel B (algebraic addition).

Each channel (2)

Bandwidth: (3 dB down from 6 div reference signal from a terminated 50 ohm source.) dc-coupled, dc to 150 MHz; ac-coupled, 10 Hz to 150 MHz.

Rise time: <2.4 ns (measured from 10% to 90% points of 6 div input step from a terminated 50 ohm source).

Deflection factor

Ranges: 5 mV/div to 5 V/div (10 calibrated positions) in 1, 2, 5 sequence, ±2% with vernier in calibrated position.

Vernier: continuously variable between all ranges, extends maximum deflection factor to at least 12.5 V/div. Vernier uncalibrated light indicates when vernier is not in Cal position.

Polarity: NORM or INV, selectable on channel B.

Signal delay: input signals are delayed sufficiently to view leading edge of input signals without external trigger.

Input RC (selectable)

High Z: 1 meg ohm ±1% shunted by approx 12 pF.

50 ohm: 50 ohms ±1%. VSWR, <1:3:1 on all ranges to 150 MHz.

Input coupling: selectable, AC or DC (1 megohm), DC (50 ohms), or Ground. Ground position disconnects input connector and grounds amplifier input.

Maximum input

High Z: 150 V (dc + peak ac) at 1 kHz on 5 mV range increasing to 300 V (dc + peak ac) on all other ranges.

50 ohm: 10 V rms (dc-coupled input).

A + B operation: bandwidth and deflection factors are unchanged, channel B may be inverted for A-B operation.

Trigger source: selectable from channel A, channel B, or normal.

Channel A: all display modes triggered by channel A signal.

Channel B: all display modes triggered by channel B signal.

Normal: all display modes triggered by displayed signal except CHOP; CHOP triggered by channel A.

Vertical output

Amplitude: one div input deflection produces approx 25 mV output.

Cascaded deflection factor: 1 mV/div with both vertical channels set to 5 mV/div.

Cascaded bandwidth: dc to 35 MHz when supplied BNC connectors are used to connect channel A vertical output to channel B input.

PORTABLE, 150 MHz
Delayed sweeps to 2 ns/div
Model 1710A

Coupling: dc.
Vertical output dc level: approx 0 V.
Vertical output resistance: approx 150 ohms.
Vertical output selection: TRIG SOURCE set to A TRIG selects channel A output; TRIG SOURCE set to B TRIG selects channel B output.

Main time base

Sweep modes: Main, Mixed, and Delayed.
Sweep
Ranges: from 20 ns/div to 0.2 s/div (22 ranges) in 1, 2, 5 sequence. ±3% accuracy over full scale with vernier in calibrated position.
Vernier: continuously variable between all ranges, extends slowest sweep to at least 0.5 s/div. Vernier uncalibrated light indicates when vernier is not in Cal position.
Magnifier: expands all sweeps by a factor of 10 and extends fastest sweep to 2 ns/div. Magnified sweep accuracy is 5% (includes 3% accuracy of the time base).
Sweep trigger mode
Normal: sweep is triggered by an internal or external signal.
Automatic: bright baseline displayed in absence of input signal. Triggering is same as normal above 40 Hz.
Single: in Normal mode, sweep occurs once with same triggering as normal, reset pushbutton arms sweep and lights indicator; in Auto mode, sweep occurs once each time Reset pushbutton is pressed.

Triggering

Internal: dc to 20 MHz on signals causing 0.3 divisions or more vertical deflection, increasing to 1 division deflection to 150 MHz in all display modes. Triggering on line frequency is also selectable.
HF stability: increases high frequency trigger sensitivity (>20 MHz).
External: dc to 20 MHz on signals of 50 mV p-p or more, increasing to 200 mV p-p at 150 MHz.
External input RC: approx 1 megohm shunted by approx 20 pF.
Level and slope: internal, at any point on the vertical waveform displayed; external, continuously variable from +1.5 to −1.5 V on either slope of the trigger signal: +15 V to −15 V in ÷ 10 on main time base only. Maximum input, ±100 V.
Coupling: AC, DC, LF REJ, or HF REJ.
AC: attenuates signals below approx 10 Hz.
LF REJ: attenuates signals below approx 50 kHz.
HF REJ: attenuates signals above approx 50 kHz.
Trigger holdoff: time between sweeps continuously variable.

Delayed time base

Sweep
Ranges: 20 ns/div to 0.1 s/div (21 ranges) in 1, 2, 5 sequence. ±3% accuracy over full scale with vernier in calibrated position. Selected independently of main time base setting (must sweep faster than main time base).
Vernier: continuously variable between all ranges, extends slowest sweep to at least 0.25 s/div. Vernier uncalibrated light indicates when vernier is not in Cal position.
Magnifier: same as main time base.
Triggering
Internal: same as main time base.
Automatic: delayed sweep automatically starts at end of delay period.
Trigger: delayed sweep is armed at end of delay period.
Level and slope: internal, at any point on the vertical waveform displayed when in triggered mode; external, continuously variable from +1.5 V to −1.5 V on either slope of the trigger signal.
Coupling: selectable, AC or DC. AC attenuates signals below approx 10 Hz.
External: dc to 20 MHz on signals of 50 mV p-p or more, increasing to 200 mV p-p at 150 MHz.
External input RC: approx 1 megohm shunted by approx 20 pF.
Delay time: continuously variable from 0.02 μs to 2 s; accuracy ±1%; linearity ±0.2%.
Delay jitter: 0.005% (1 part in 20,000) of max. delay in each step.
Trace intensification: intensifies that part of main time base to be expanded to full screen in delayed time base mode. Rotating delayed time base switch from OFF position activates intensified mode.
Mixed time base: dual time base in which main time base drives first portion of sweep and delayed time base completes the sweep up to 1000 times faster. Also operates in single sweep mode.

External horizontal input

Bandwidth: dc to 5 MHz when driven directly from a terminated 50 ohm source.
Coupling: dc.
Deflection factor (with beam positioned at left edge of CRT): X1,250 mV/div; X10,25 mV/div.
Vernier: 3:1 vernier provides continuous adjustment between ranges when in X-Y operation.
Dynamic range: beam may be positioned to left edge of CRT with 0 to −3 V input.
Maximum input: ±15 V.
Input RC: 1 megohm shunted by approx 20 pF.
X-Y operation: vertical output from either channel may be applied to EXT HORIZ INPUT for calibrated X-Y operation. Deflection factor is read directly from input channel when in the X10 mode.

Cathode-ray tube and controls

Type: post-accelerator, ≈ 22 kV accelerating potential; aluminized P31 phosphor.
Graticule: 6 x 10 div internal graticule; 0.2 subdivisions on major horizontal and vertical major axes. 1 div = 1 cm. Front panel adjustment aligns trace with graticule.
Beam finder: returns trace to CRT screen regardless of setting of horizontal, vertical, or intensity controls.
Intensity modulation: >+6 V, dc to 1 MHz blanks trace of any intensity. Input R, 1000 ohms ±10%. Max input ±10 V (dc + peak ac).
Bright scan: provides 3 x 5 cm (½ cm/div) display at more than twice the brightness of 6 x 10 cm display. Display remains calibrated.

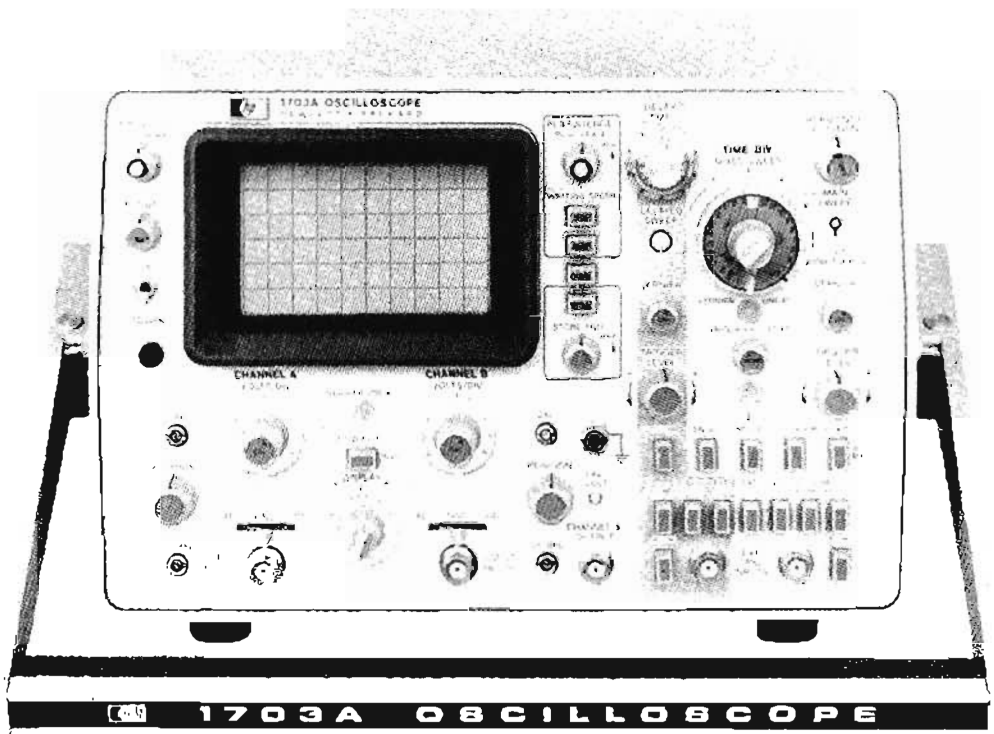
General

Outputs: rear panel outputs for main sweep and for main and delayed gates.
Calibrator: 1 kHz, ±10% square wave; 1 V p-p, ±1%; 5 mA, ±2%.
Power: 115 or 230 V ±20%, 48 to 440 Hz, 75 VA max.
Weight
Without panel cover: net, 31 lb (14,1 kg); shipping, 42 lb (23,7 kg).
With panel cover and accessories: net, 34 lb (15,4 kg); shipping, 46 lb (25,4 kg).
Dimensions: 12-13/16" wide, 7¾" high, 22¾" long with handle, 17⅝" without handle (325 x 198 x 578 (448) mm).
Operating environment: Temperature, 0°C to +55°C. Humidity, at 95% relative humidity to 40°C; altitude: to 15,000 ft; vibration, vibrated in three planes for 15 min. each with 0.010 inch excursion, 10 to 55 Hz.
Accessories furnished: one Model 10115A blue light filter; one Model 10101B front panel storage cover; two Model 10014A, 10:1 divider probes, 3.5 ft (1,1 m) long; one 7.5 ft (2,3 m) power cord with right angle plug; BNC connectors for cascading channel A into B, two right angle BNC male to female connectors (HP P/N 1250-0076), one BNC male to male connector (HP P/N 1250-0216); and one Operating and Service manual.
Price: Model 1710A 150 MHz Oscilloscope $2300

PORTABLE, 35 MHz

Rugged storage/variable persistence

Models 1702, 1703A, 1705A



1703A

Description models 1702A, 1703A, 1705A

Models 1702A, 1703A, and 1705A have the same basic vertical and time base operating features as the 1700B and 1701B with the added capabilities of variable persistence and storage cathode-ray tubes. These storage oscilloscopes offer laboratory performance in a rugged portable package and are the first storage oscilloscopes to give you ac, dc, or battery operation. Model 1702A has a single time base while Models 1703A and 1705A have a calibrated delayed sweep. All models have 35 MHz bandwidths, dual channel 10 mV/div deflection factors, and 10 ns/div sweep speeds.

Hewlett-Packard's storage mesh CRT allows you to adjust the amount of time a trace is retained, from less than one second to over one hour. Two of the most useful features of the variable persistence mode are to provide extra brightness for dim traces (such as low rep-rate pulses) and to eliminate flicker with slow sweep speeds.

100 cm/μs storage writing speed

Model 1705A variable persistence and storage portable provides a writing speed of 100 cm/μs. This writing speed is so fast that traces you previously had to photograph to see can now be viewed directly in normal ambient light. A unique FAST mode optimizes writing speed by switching the CRT display to reduced scan while maintaining full calibration and resolution. A second graticule, for the fast mode, is superimposed in the center of the screen and a front panel light indicates when the scope is in the FAST mode. This writing speed allows you to store a single shot 10 ns rise time transient or a 25 MHz sinewave with an amplitude of 1 cm.

These oscilloscopes have three basic uses: 1) as a conventional scope; 2) as a variable persistence scope; and 3) as a storage scope.

Conventional scope

The oscilloscopes can be used in most applications requiring a conventional CRT. They have a bright, crisp trace and the CRT linearity, bandwidth, and deflection factors are specified over the entire 6 x 10 division (0.85 cm/div) display, from dc to 35 MHz.

They all have Hewlett-Packard's new burn resistant tube. In fact, they only require the same operating care of a conventional cathode-ray tube.

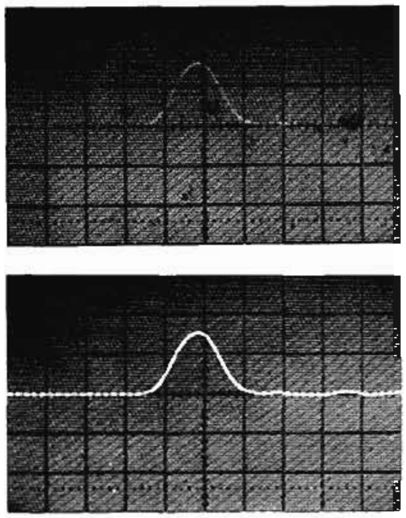
Variable persistence scope

Variable persistence capability in a scope enhances conventional CRT viewing in at least two measurement situations.

Building-up brightness of dim traces

Low duty-cycle, low rep-rate pulses are encountered in a broad spectrum of applications, from purely digital systems to electro-mechanical devices. The problem with viewing these waveforms is that the sweep speed is usually fast in order to see the rise time, but at the same time the repetition rate is much lower than the normal persistence of the phosphor. This results in a very dim trace and usually a viewing hood is necessary to see it.

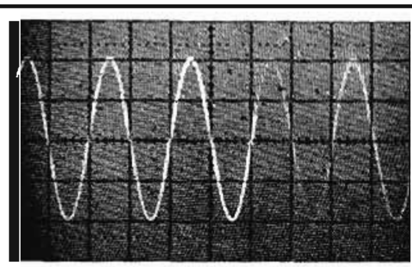
This is where variable persistence really helps. You can adjust the persistance so that you "build-up" the intensity of the trace through repeated sweeps. The result is a bright, clear trace.



These two photos illustrate (a) a low rep rate pulse viewed in the conventional mode at maximum brightness, and (b) the improved brightness you get by switching to variable persistence. Increasing the persistence lets you "build-up" the intensity through repeated sweeps.

Eliminating flicker

Variable persistence is also useful for eliminating flicker due to using slow sweep speeds on slowly changing waveforms. At sweep speeds below 1 ms/div, CRT flicker can be annoying, and at very slow sweep speeds, measurements are difficult to make. This is because natural persistence of commonly used phosphors is short relative to the sweep speed. With variable persistence, you increase the persistence so that your waveform is retained as long as you like. You can adjust the persistence, for example, so that one sweep is just disappearing from the CRT as the next sweep comes along.



Slowly changing waveforms at slow sweep speeds are easy to see with variable persistance. The persistance has been adjusted so that the trace from one sweep is just disappearing as the next sweep comes along. Sweep speed is 0.1 sec/div, signal is 5 Hz sinewave.

Storage scope

The third basic use is as a storage scope. With storage, you can capture single shot events, such as noise related transients, or infrequently occuring events, such as a random bit dropout. Just push STORE and your waveform will be preserved for over an hour. This feature replaces a conventional scope and camera (with the associated inconveniences) for most applications.

If the event to be stored has random occurence, a special feature that arms the storage circuits but turns off the flood-guns may be used. By simultaneously pushing STORE and one of the writing speed pushbuttons, you have the maximum time to wait for the event to happen without the CRT background fading. The stored trace will not be visible until the writing speed pushbutton is released.

Specifications, 1702A, 1703A, 1705A

Modes of operation: channel A; channel B, channels A and B displayed alternately on successive sweeps (ALT); channels A and B displayed by switching between channels at approx 400 kHz rate with blanking during switching (Chop); channel A + channel B (algebraic addition).

Each vertical amplifier channel (2)

Bandwidth: (direct or with Model 10006B probe. 3 dB down from 50 kHz, 6 div reference signal from a terminated 50 ohm source). DC-coupled, dc to 35 MHz; ac-coupled, lower limit is approx 10 Hz.

Risetime: <10 ns. Direct or with Model 10006B probe. 10% to 90% points with 6 div input step from a terminated 50 ohm source.

Deflection factor

Ranges: from 10 mV/div to 5 V/div (9 ranges) in 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between all ranges, extends maximum deflection factor to at least 12.5 V/div.

Polarity: NORM or INV, selectable on channel B.

Signal delay: input signals are delayed sufficiently to view leading edge of input signals without advanced external trigger.

Input RC: 1 megohm ±1%, shunted by approx 27 pF.

Input coupling: AC, DC, or Ground selectable. Ground position disconnects signal input and grounds amplifier input.

Maximum input

AC-coupled: ±600 V (dc + peak ac); rms ac <350 V, 5 V/div to 20 mV/div; <150 V at 10 mV/div (10 kHz or less).

DC-coupled: <350 V (rms) 5 V/div to 20 mV/div; <150 V at 10 mV/div (10 kHz or less).

A + B operation

Amplifier: bandwidth and deflection factors are unchanged; channel B may be inverted for A-B operation.

Common mode (A-B): frequency, dc to 1 MHz; rejection ratio, at least 40 dB on 10 mV/div, at least 20 dB on all other ranges with verniers set for optimum rejection. Common mode signal amplitude equivalent to 30 div.

Trigger source

(applies for all five modes of operation)

Norm: on displayed signal.

A only: on signal from channel A.

Triggering

Internal: dc to 35 MHz on signals causing 0.5 div or more vertical deflection increasing to 1.5 div at 75 MHz in all display modes except chop, dc to 400 kHz in chop mode. Triggering on line frequency is also selectable.

External: dc to 35 MHz on signals 50 mV p-p or more, increasing to 100 mV p-p at 75 MHz.

External input RC: approx 1 megohm shunted by approx 27 pF.

Level and slope: internal, at any point on the vertical waveform displayed; external, continuously variable from +1.2 V to −1.2 V on either slope of the trigger signal. Maximum input, +100 V. In Model 1702A ÷ 10 extends external trigger input range to +12 V to −12 V.

Coupling: AC, DC, LF REJ, or HF REJ.

AC: attenuates signals below approx 20 Hz.

LF-REJ: attenuates signals below approx 15 kHz.

HF-REJ: attenuates signals above approx 30 kHz.

Trigger holdoff: time between sweeps continuously variable.

Time base

Sweep

Ranges: from 0.1 μs/div to 2 s/div (23 ranges) in 1, 2, 5 sequence ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between all ranges, extends slowest sweep to at least 5 s/div. Vernier uncalibrated light indicates when vernier is not in calibrated position.

Magnifier: expands all sweeps by a factor of 10 and extends fastest sweep to 10 ns/div. Accuracy ±5% (including 3% accuracy of time base).

PORTABLE, 35 MHz

Delayed, non-delayed sweeps, dual channel

Models 1702A, 1703A, 1705A

Sweep mode

Normal: sweep is triggered by an internal or external signal.

Automatic: bright baseline displayed in absence of input signal. Triggering is same as normal above 40 Hz.

Single: in Normal mode, sweep occurs once with same triggering as normal: reset pushbutton arms sweep and lights indicator; in Auto mode, sweep occurs once each time Reset pushbutton is pressed.

Delayed time base

Models 1703A and 1705A

Trace Intensification: intensifies that part of main time base to be expanded to full screen in delayed time base mode. Rotating time base switch from OFF position activates intensified mode.

Sweep

Ranges: 0.1 μs/div to 0.2 s/div (20 ranges) in 1, 2, 5 sequence. ±3% accuracy with vernier in calibrated position.

Vernier: continuously variable between all ranges, extends slowest sweep to 0.5 s/div.

Magnifier: expands all sweeps by a factor of 10 and extends fastest sweep to 10 ns/div. Accuracy is ±5% (including 3% accuracy of time base).

Sweep mode

Trigger: delayed sweep is armed at end of delay period.

Auto: delayed sweep automatically starts at end of delay period.

Triggering

Internal: same as main time base.

External: same as main time base. Input RC is approx 1 megohm shunted by approx 27 pF.

Level and slope: internal, at any point on the vertical waveform displayed; external, continuously variable from +1.2 V to −1.2 V on either slope of the trigger signal.

Coupling: selectable, ac or dc. AC attenuates signals below approx 20 Hz.

Delay (before start of delayed sweep)

Time: continuously variable from 0.1 μs to 2 s.

Time jitter: <0.005% (1 part in 20,000) of max delay in each sweep.

Calibrated delay accuracy: ±1%; linearity, ±0.2%.

Mixed sweep: combines main and delayed sweeps into one display. Sweep is started by the main time base and is completed by the faster delayed time base.

External horizontal input

Bandwidth: dc to 1 MHz when driven directly from a terminated 50 ohm source.

Coupling: dc.

Deflection factor (with beam positioned at left edge of CRT): X1, 1 V/div; X10, 0.1 V/div.

Vernier: 10:1 vernier extends deflection factor to at least 10 V/div (X1) or 1 V/div (X10).

Dynamic range: beam may be positioned at left edge of CRT with 0 V to −5 V input.

Maximum input: ±100 V.

Input RC: 1 megohm shunted by approx 10 pF.

Channel A output

Amplitude: one division of displayed signal in channel A produces approx 100 mV output.

Cascaded deflection factor: 1 mV/div with both vertical channels set to 10 mV/div.

Cascaded bandwidth: dc to 3 MHz (use HP Model 10121A BNC cable supplied to connect channel A output to channel B).

Coupling: dc.

Vertical output dc level: approx 0 V.

Vertical output resistance: approx 200 ohms.

All models

Cathode-ray tube and controls

Type: post-accelerator, ≈ 8.3 kV accelerating potential; aluminized P31 phosphor.

Graticule: 6 x 10 div internal graticule; 0.2 subdivisions on major horizontal and vertical axes. 1 div = 0.85 cm. In Model 1705A, an 8 x 10 div internal graticule is superimposed in center of normal graticule (1 div = 0.425 cm) for fast writing speed mode. Rear panel adjustments for trace align and astigmatism.

Beam finder: returns trace to CRT screen regardless of setting of horizontal or vertical controls.

Intensity modulation: +4 V, dc to 1 MHz blanks trace of any intensity. Input R, 1000 ohms ±10%. Max. input, ±10 V (dc + peak ac).

Writing modes: conventional (non-storage), standard and fast (variable persistence and storage). Pressing STORE and either STD or FAST provides max persistence with flood guns off for a ready-to-write state. The CRT will remain primed and ready-to-write for the times specified for storage writing speed.

Persistence

Conventional: natural persistence of P31 phosphor (approx 40 μs).

Variable: from <50 ms to >1 min.

Storage writing speed

Model	STD Mode	FAST Mode
1702A/1703A	>20 cm/ms*	>10000 cm/ms*
1705A	>0.2 cm/μs*	>100 cm/μs**

*Measured over central 5 x 9 divisions.
**Measured in reduced scan graticule area.

Storage time: from standard mode to store, traces may be stored at reduced intensity for >2 hours. With STORE TIME in full ccw position, traces may be viewed at normal intensity for >1 minute. From Fast Mode to Store, traces may be stored at reduced intensity for 5 minutes. With STORE TIME in full ccw position, traces may be viewed at normal intensity for >15 seconds.

Erase: manual, pushbutton erasure takes approx 500 ms.

General

Calibrator: squarewave output, 1 kHz, ±10% 1 V p-p ±1%.

Power requirements: ac line: 115 or 230 V ±20%, 48 to 440 Hz, 50 VA max; dc line: 11.5 to 36 V, 25 watts max.

Battery (optional)

- **Operating time:** up to 4 hours.
- **Recharge time:** 14 hours maximum, with power switch off, if not operated after power indicator flashes.
- **Low battery indicator:** power light flashes to indicate that batteries are discharged and further operation may damage battery.
- **Recharging:** batteries are recharging whenever power mode switch is set to AC with power switch on, trickle charge is applied.

Weight

- **Without panel cover:** net, 24 lb (1 kg); shipping, 35 lb (15.9 kg).
- **With panel cover and accessories:** net, 27 lb (12.3 kg); shipping, 38 lb (17.2 kg).
- **With panel cover, accessories, and battery pack:** net, 35 lb (16 kg); shipping, 46 lb (20.9 kg).

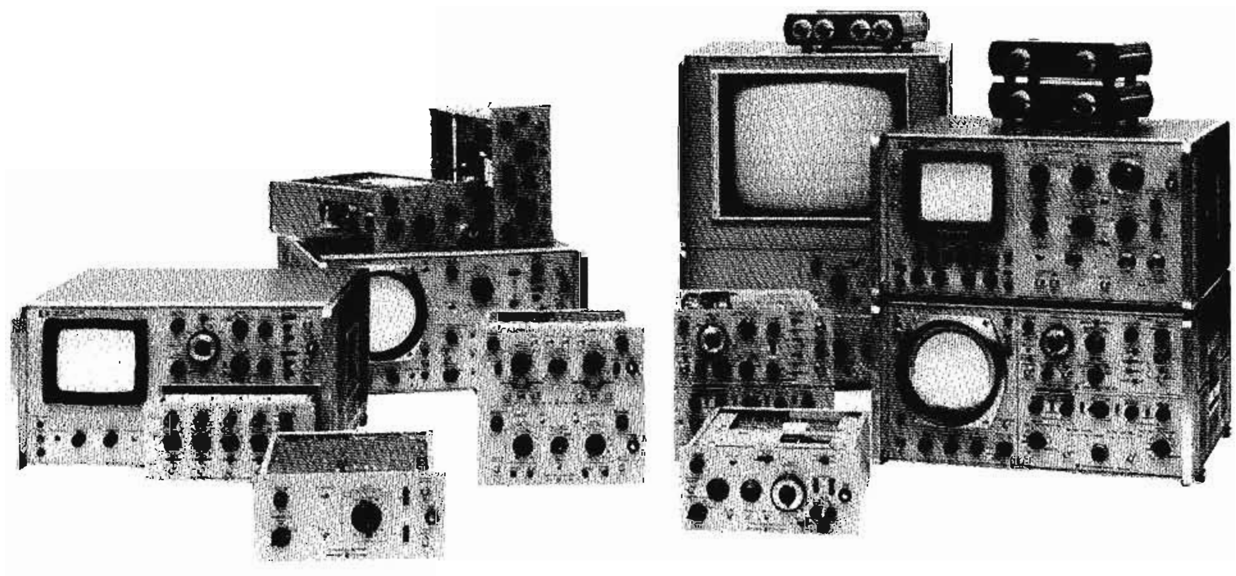
Operating environment: temperature 0°C to +55°C; humidity, to 95% relative humidity to 40°C. altitude, to 15,000 ft; vibration, vibrated in three planes for 15 min. each with 0.010 inch excursion, 10 to 55 Hz.

Accessories furnished: one Model 10115A blue light filter; one Model 10101B front panel storage cover; two Model 10006B, 10:1 divider probes, 6 ft (1.8 m) long; one 7.5 ft (2.3 m) power cord with right angle plug (HP P/N 8120-1521); and one Operating and Service manual.

Price

Model 1702A Storage Oscilloscope	$2375
Model 1703A Delayed Sweep Storage Oscilloscope	$2725
Model 1705A Delayed Sweep High Speed Oscilloscope	$3000
Option 012: Model 10103B Battery Pack installed	add $ 215

PLUG-IN OSCILLOSCOPE
One scope for many measurements
Model 140 System



140 System

The Hewlett-Packard 140 Oscilloscope System provides the versatility you need for measurements over the entire oscilloscope spectrum. With many high performance vertical and horizontal plug-ins to choose from, you can head in any measurement direction; wide-band sampling, high-sensitivity, delayed sweep, or measurements such as time domain reflectometry, swept frequency, or spectrum analysis.

Hewlett-Packard's 140 oscilloscope system offers these capabilities:

- Sampling bandwidth to 18 GHz.
- Sampling delayed sweep time base.
- 50 μV/div deflection factors.
- Versatile single or double-size plug-in capability.
- Direct readout TDR.
- Swept frequency.
- Spectrum analyzer plug-ins.

In addition, the system offers standard CRT persistence in either the 140B, or 143A mainframes; or variable persistence and storage in the 141B mainframes. Select from these unique measurement capabilities or from the general purpose plug-ins available.

High-performance mainframes

The advanced 140B, 141B, and 143A mainframes give you a choice between conventional (fixed) CRT persistence, variable persistence and storage, and 8" x 10" CRT displays. As a result, the 140 system not only has an extensive plug-in capability, but also, the CRT versatility needed to meet the requirements of measurement problems today—six months from now—or in the distant future.

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

Further, since the 140 system CRT's have identical horizontal and vertical deflection factors 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.

Variable persistence and storage

The 141B mainframe gives you all the advantages of the 140B mainframe—plus the benefits of variable persistence and storage. At the twist of a knob, you can adjust trace persistence from 0.2 seconds to more than a minute. This 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.

The Hewlett-Packard mesh storage tube offers many advantages which include: A highly burn resistant storage surface that does not require special operating procedures; a stored trace with the same high contrast and visual brightness of a conventional CRT; and intermediate trace values are easily distinguishable.

18 GHz sampling with delayed sweep

You can see through P band, observe CW signals to 18 GHz and beyond, and see fast pulses with 20 ps risetime 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, the delayed sweep can be used through the full bandwidth for displays of pulse segments that leave conventional sampling scopes blurred. You also get less than 20 ps jitter to ensure steady, clear displays.

MEASUREMENTS FROM DC TO 18 GHz

1, 2, or 4 channels, standard/delayed sweeps

Model 140 System

Two vertical amplifiers are available. Model 1411A provides dc to 18 GHz at 1 mV/div, 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 50 ohm 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/div zero drift

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

With the Hewlett-Packard 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.

2-channel 20 MHz bandwidth, 4-channel displays to 15 MHz, and delayed sweep

If you need wideband real time performance, for example, you can use the dual-trace 1402A vertical amplifier and get dc to 20 MHz (15 MHz with Model 143A) at 5 mV/div, algebraic addition, built-in delay line for viewing the leading edge of fast-rise pulses, full 6 div deflection and a wide dynamic range. An internal sync amplifier triggers on Channel A in dual trace mode of operation—gives stable traces and accurate time measurements without external triggering.

When you need to display four channels of information, you can use the 4-trace 1404A vertical amplifier and get dc to 15 MHz at 10 mV/div or 1 mV/div to 10 MHz, algebraic addition, and built-in delay line for viewing the leading edge of fast-rise pulses. Internal trigger circuits allow you to trigger on channel A, B, C, or D or select composite triggering, which triggers each channel individually.

For easy readability of complex waveforms and accurate time interval measurements, Model 1421A Time Base & Delay Generator provides calibrated time delays from 10 seconds to 0.5 μs, calibrated sweep speeds from 0.2 μs/div to 20 ns/div. The 1421A also offers mixed sweep which displays the first portion of a trace at normal sweep speeds, and expands the trailing portion of the trace at faster delayed sweep speeds to allow step-by-step magnified examination.

Spectrum analyzer plug-ins for measurements in the frequency domain

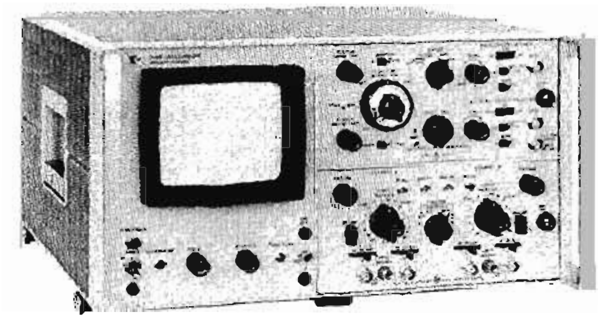
By a simple addition of Spectrum Analyzer plug-ins, you can convert your time-domain oscilloscope into a frequency-domain instrument with coverage from 20 Hz to 40 GHz. These spectrum analyzer plug-ins have absolute amplitude calibration, high sensitivity, low distortion, wide dynamic range, and flat frequency response. See page 452 for information about these plug-ins.

140 Series Plug-in Selection Chart

Vertical Plug-in	REALTIME						SAMPLING			TDR	Swept Freq.
Capabilities	1400B	1402A	1404A	1405A	1406A	1408A	1410A	1411A/1430C	1411A/1432A	1415A	1416A
Bandwidth	500 kHz	20 MHz	15 MHz	5 MHz	400 kHz	500 kHz	1 GHz	18 GHz	4 GHz		
Deflection Factor/div	100 μV	5 mV	10 mV	5 mV	50 μV	100 μV	1 mV	1 mV	1 mV		
Channels	1	2	4	2	1	2	2	2	2		
X-Y	X	X	X	X	X	X	X	X	X		
Delayed Sweep			1421A for Realtime				1425A for Sampling				
No Drift					X						
Max. CMRR in dB	100	40	40	40	60	100					
Algebraic Add.		X	X	X		X	X	X	X		
TDR										X	
Wide Band TDR								X			
Swept Freq.											X
RECOMMENDED TIME BASES											
1421A	X	X	X	X	X	X					
1423A	X	X	X	X	X	X					
1424A							X	X	X		
1425A							X	X	X		
SPECTRUM ANALYZER SYSTEM PLUG-INS	Refer to Page 452 for 8550 Series Plug-ins.										

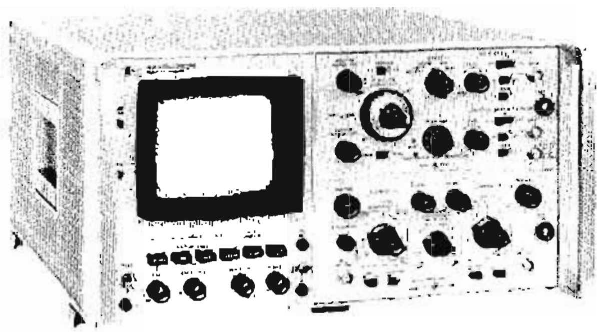
SELECT FROM 3 MAINFRAMES

Standard, storage, large screen CRTs
Model 140 System



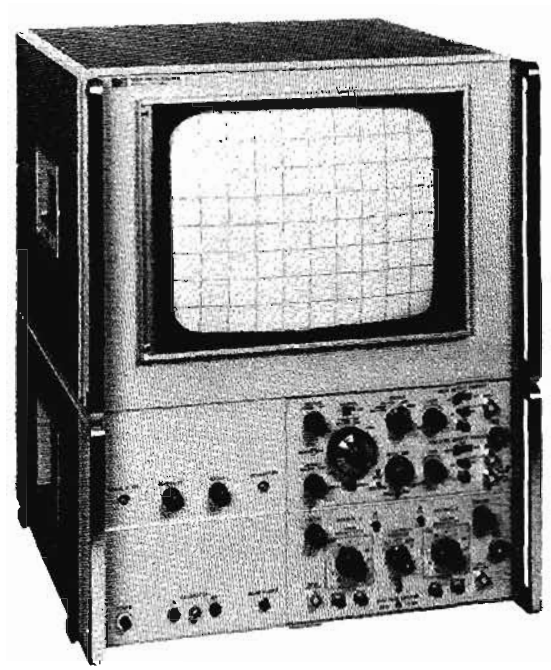
140B

- 8 x 10 div internal graticule
- Bright display
- Convenient beam finder
- Price: $795 (less plug-ins)



141B

- Variable persistence and storage
- Bright stored displays
- 8 x 10 div internal graticule
- Convenient beam finder
- Price: $1600 (less plug-ins)



143A

- Large, 8 x 10 in. viewing area
- Bright, easy-to-see displays
- 8 x 10 div internal graticule
- Convenient beam finder
- Price: $1700 (less plug-ins)

Description, 140 mainframes

The HP 140 Oscilloscope System provides the versatility you need for measurements over the entire oscilloscope spectrum. With many high-performance plug-ins to choose from, you can head in any measurement direction: wideband, sampling, high sensitivity, time domain reflectometry, swept frequency, and spectrum analysis.

The HP 140-system mainframes are designed to give you high-frequency and high-sensitivity performance. The mainframe contains a post-accelerator CRT with associated control circuits and power supplies and the power supplies for the plug-ins.

The 141B mainframe gives you all the advantages of the 140 mainframe plus the benefits of a mesh CRT with variable persistence and storage.

This variable persistence allows you to adjust 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 low-frequency displays.

With the mesh storage tube, a stored trace has the same high contrast as a conventional CRT and intermediate trace values are easily distinguished between four or five different trace intensities. Trace intensity can be controlled from the front panel or externally modulated for X-Y-Z presentations.

Another 140-System feature is the large screen, 8 x 10 inch viewing area, 143A mainframe, which is useful when the display is to be viewed from a distance or by many people at one time. The Model 143A provides high resolution displays throughout the oscilloscope spectrum with the same accuracy and linearity associated with conventional 5-inch displays.

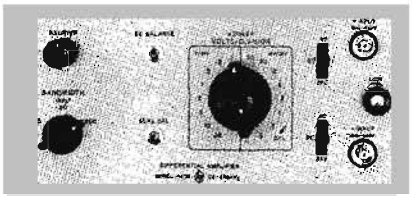
For complete specifications about the 140 System, refer to the 140 System data sheet or contact your Hewlett-Packard field engineer.

For complete 140 System specifications, contact your Hewlett-Packard field engineer.

DC TO 20 MHz - REAL TIME

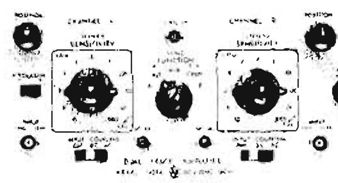
Single & Delayed Time Bases

Model 1400 series plug-ins



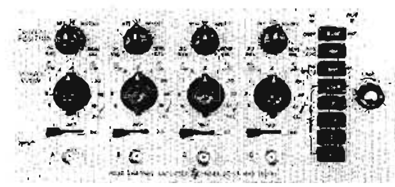
1400B

- 100 μV/div
- dc to 500 kHz
- Differential on all ranges
- 100 dB CMRR
- Price: $350



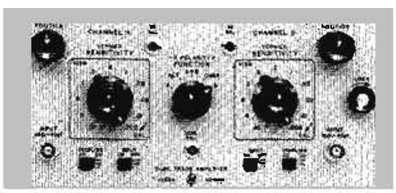
1402A

- 5 mV/div
- dc to 20 MHz-dual trace
- Signal delay for fast rise viewing
- Price: $675



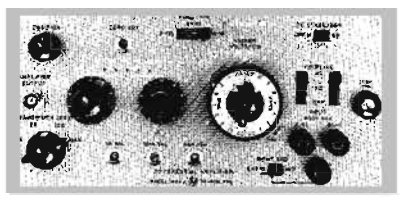
1404A

- 10 mV/div to 15 MHz
- 1 mV/div to 10 MHz
- Signal delay for fast rise viewing
- Selectable triggering
- Price: $1100



1405A

- 5 mV/div-dual trace
- dc to 5 MHz
- Algebraic addition
- Price: $455

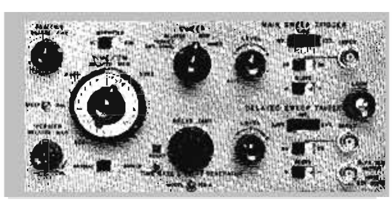


1406A

- 50 μV/div-dc to 400 kHz
- No drift
- Calibrated offset for accurate ac and dc measurements
- Price: $1025

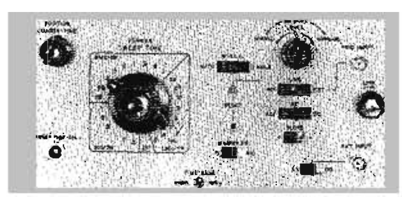
1408A

- 100 μV/div-dual channel
- dc to 500 kHz
- 100 dB CMRR
- Alternate or chopped sweeps
- Price: $625



1421A

- 20 MHz triggering
- Delayed sweep
- Sweeps to 20 ns/div
- Price: $750

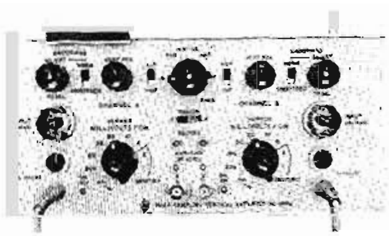


1423A

- 20 MHz triggering
- Sweeps to 20 ns/div
- Trigger hold-off
- Price: $485

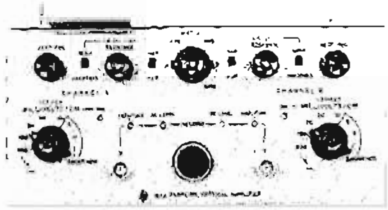
For complete 140 System specifications, contact your Hewlett-Packard field engineer.

DC TO 18 GHz SAMPLING
TDR, SWEPT FREQUENCY
Model 1400 series plug-ins



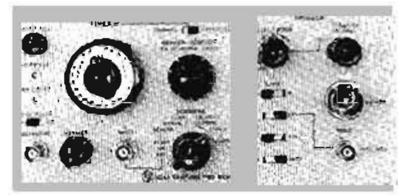
1410A

- 1 mV/div at 1 GHz dual trace
- Internal triggering
- High impedance probes and 50Ω inputs
- Price: $1800



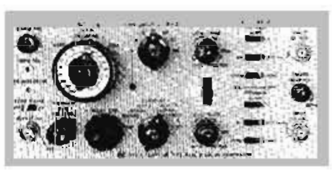
1411A

- 1 mV/div·dual trace
- Bandwidths to 18 GHz
- Remote samplers
- Price: $850



1424A

- Triggering to 5 GHz
- Sweeps to 10 ps/div
- Direct readout on all sweeps
- Price: $1475



1425A

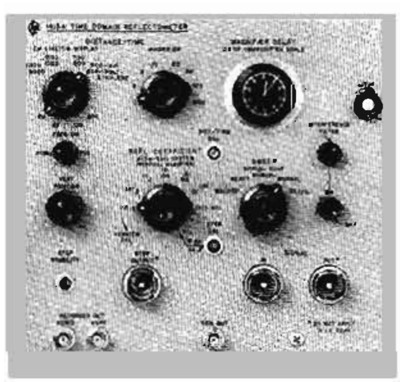
- Delayed sweep
- Sweeps to 10 ps/div
- Triggering to 1 GHz
- Price: $2150

1430C

- 20 ps risetime
- Price: $2800

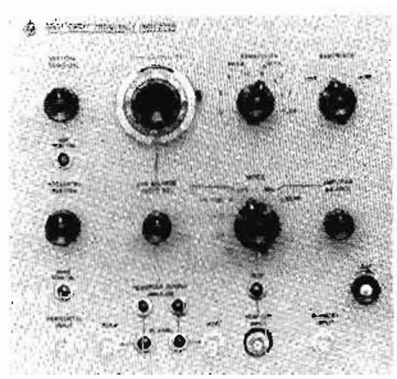
1432A

- 90 ps risetime
- Price: $1185



1415A

- Complete TDR system for testing cables, connectors, striplines
- Determines location, meaning, and nature of each discontinuity
- Resolves discontinuities—an inch apart
- Easy to operate
- Price: $1200

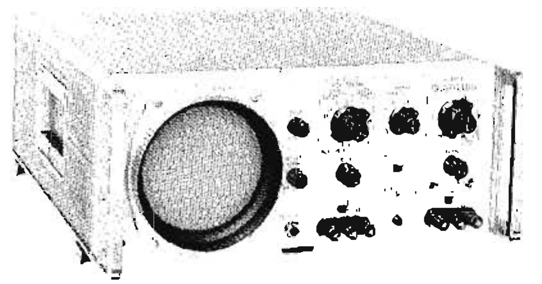


1416A

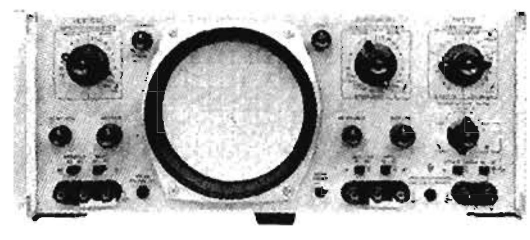
- Speeds and simplifies swept frequency measurements
- High resolution direct readout in dB
- Low drift
- X-Y recorder outputs
- Price: $1050

For complete 140 System specifications, contact your Hewlett-Packard field engineer.

SYSTEM & TV WAVEFORM
Low cost, easy-to-use
Models 120B, 130C, 191A



120B



130C

Models 120B and 130C have applications in a few specialized systems and have abbreviated specifications. If complete specifications are required, contact your Hewlett-Packard Field Engineer.

Specifications, 120B

Time base

Range: 5 μs/cm to 200 ms/cm ±5%, 1 μs/cm in x5 ±10%.

Triggering

Automatic: internal, 50 Hz to 450 kHz for most signals of 1.0 cm vertical deflection; external, 50 to 450 kHz for signals 1.5 V p-p.

Amplitude selection: internal, 10 Hz to 450 kHz for signals >0.5 cm vertical deflection; external, 10 Hz to 450 kHz for signals 1.5 V p-p.

Trigger level and slope: from any point on the vertical waveform presented on CRT; or continuously variable from −7 to +7 volts on the negative slope of external sync signal.

Vertical amplifier

Bandwidth: dc to 450 kHz; lower limit 2 Hz when ac-coupled.

Deflection factor: 10 mV/cm to 10 V/cm in 4 steps, ±3%; vernier extends 10 V/cm step to at least 100 V/cm.

Maximum input: 50 V peak (dc + ac).

Balanced input: on 10 mV/cm range, common mode rejection is at least 40 dB; common mode signal ±3 V peak.

Phase shift: vertical to horizontal, ±2° to 100 kHz (with verniers in Cal).

Horizontal amplifier

Bandwidth: dc to 300 kHz; lower limit is 2 Hz when ac-coupled.

Deflection factor: 0.1 V/cm to 10 V/cm in 3 steps, ±5%; vernier extends 10 V/cm step to at least 100 V/cm

General

Cathode-ray tube: 2700 V mono-accelerator, P31 phosphor.

Graticule: 10 cm x 10 cm internal graticule.

Beam finder: returns trace to CRT screen.

Intensity modulation: +20 V, pulse blanks normal intensity trace.

Dimensions: 16¾" wide, 7½" high, 18⅜" deep overall (425 x 191 x 467 mm); hardware furnished for quick conversion to 7" x 19" (178 x 483 mm) rack mount.

Weight: net, 29 lbs (13 kg); shipping, 35 lbs (16,9 kg).

Power: 115 or 230 volts ±10%; 50 to 400 Hz; approx 90 W.

Price: HP Model 120B Oscilloscope $675.

Specifications, 130C

Time base

Range: 1 μs/cm to 5 s/cm, ±3%; vernier extends 5 s/cm step to at least 12.5 s/cm.

Magnifier: X2, X5, X10, X20, X50; ±5% for sweeps to 0.2 μs/cm.

Automatic triggering: internal, 50 Hz to 500 kHz for signals >0.5 cm vertical deflection; external, 50 Hz to 500 kHz for signals >0.5 V p-p.

Amplitude selection triggering: internal, 10 Hz to 500 kHz for signals >0.5 cm vertical deflection; external, for signals >0.5 V p-p; dc to 500 kHz or 20 Hz to 500 kHz, ac-coupled.

Trigger level and slope: any point on the display or variable from −10 to +10 V on either slope of external sync signal.

Vertical and horizontal amplifiers

Bandwidth: dc to 500 kHz; lower limit is 2 Hz when ac-coupled.

Deflection factor: 0.2 mV/cm to 20 volts/cm, 1, 2, 5 sequence; accuracy ±3%; vernier extends 20 V/cm step to at least 50 V/cm.

Maximum input: 500 V peak (dc + peak ac).

Common mode rejection (dc to 50 kHz): 40 dB from 0.2 mV/cm to 0.1 V/cm 30 dB from 0.2 V/cm to 20 V/cm common mode signal max 4 V p-p on 0.2 V/cm range, 40 V p-p on 0.5 V/cm to 2 V/cm ranges, or 400 V p-p on 5 V/cm to 20 V/cm ranges.

Phase shift: ±1° to 100 kHz.

General

Calibrator: line frequency square wave, 500 mV ±2%.

Cathode-ray tube: 3 kV mono-accelerator.

Graticule: 10 cm x 10 cm internal graticule.

Beam finder: returns trace to CRT screen.

Intensity modulation: ±20 V pulse blanks normal intensity trace.

Dimensions: 16¾" wide, 7½" high, 18⅜" deep over-all (426 x 191 x 467 mm); hardware furnished for quick conversion to 7" x 19" (178 x 843 mm) rack mount.

Weight: net, 31 lbs (15 kg); shipping, 38 lbs (18 kg).

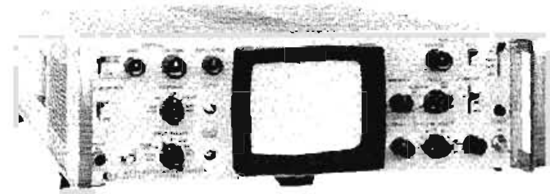
Power: 115 or 230 volts ±10%; 50 to 400 Hz; approx 90 W.

Price: HP Model 130C Oscilloscope $1065.

191A TV Waveform Oscilloscope

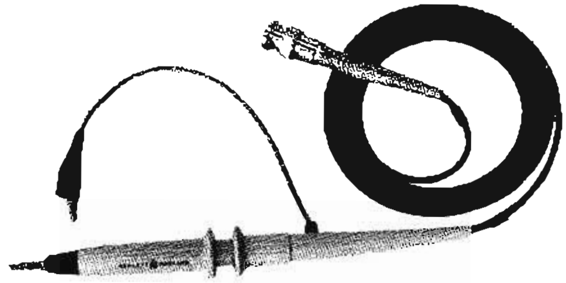
The 191A is used for accurate displays of TV video waveforms and test signals. Its accuracy of 1% in signal amplitude measurements and positive field selection on noisy signals make this scope ideal for many video applications. Other conveniences features are: 20 kV CRT for bright, easy-to-read displays and RGB operation for color camera set-up.

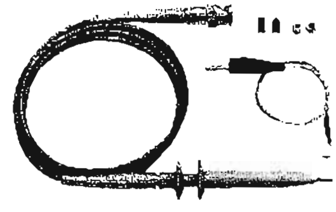
Price: Model 191A TV Waveform Oscilloscope $2075.

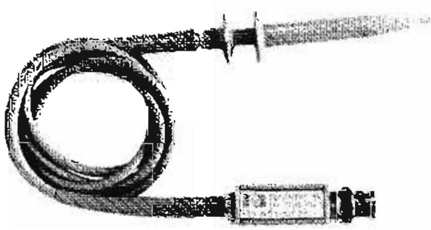


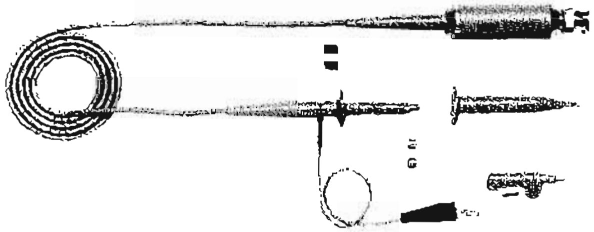
191A

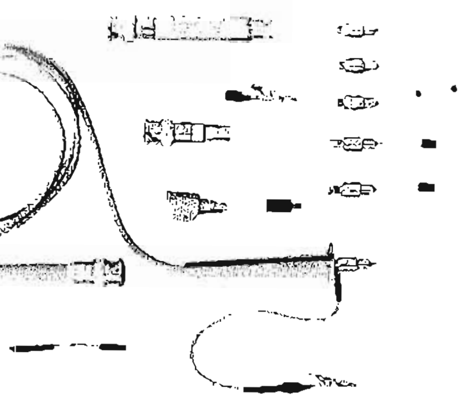
GENERAL PURPOSE PROBES
700 MHz probe for 50Ω input
Models 10020A, 10000 series


10001A


10007B


10014A


10004B


10020A

Resistive Dividers, 10020A

Division Ratio	Input R* (ohms)	Division Accuracy	Max V** (rms)	Input C (pF)
1:1	50	–	6	–
5:1	250	±3%	9	<0.7
10:1	500	±3%	12	<0.7
20:1	1000	±3%	15	<0.7
50:1	2500	±3%	25	<0.7
100:1	5000	±3%	35	<0.7

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

Length (over-all): approx 4 ft.
Weight: net, 1 lb (0,45 kg); shipping, 3 lbs (1,36 kg).
Accessories supplied: blocking capacitor, BNC adapter tip, 6-32 adapter tip, alligator tip, boot extension, cable assy's 2" and 6" ground, spanner tip, insulating cap, colored sleeve.
Price: Model 10020A, $100.

Voltage Divider Probe Specifications

Model No.	Division Ratio	Resistance MΩ	Shunt Capacitance	Compensates Scope Input Capacities	Peak Volts	Division Accuracy	Over-all Length (approx. ft.)	Price
10001A	10:1	10	10 pF	15–55	600	2%	5	$35
10001B	10:1	10	20 pF	15–45	600	2%	10	35
10002A	50:1	9	2.5 pF	15–55	1000	3%	5	40
10002B	50:1	9	5 pF	15–55	1000	3%	10	40
10003A	10:1	10	10 pF	15–55	600	2%	4	35
10004B	10:1	10	10 pF	17–30	500	3%	3.5	50
10005B	10:1	10	17 pF	17–30	500	3%	10	50
10006B	10:1	10	14 pF	17–30	500	3%	6	50
10007B	1:1	—	30 pF	—	600	—	3.5	22
10008B	1:1	—	60 pF	—	600	—	6	22
10012B	10:1	10	16 pF	30–55	500	3%	6	40
10014A	10:1	10	10 pF	9–13	500	1%	3.5	55
10016A	10:1	10	14 pF	9–13	500	1%	6	55

Probe/Instrument Compatibility

Scope/Plug-In / Probe	120B	130C	1200 Series	1700 thru 1705	1706/1707	1710A	1400B	1402A	1404A	1405A	1406A	1801A	1803A	1804A	1805A	1806A	1807A	1808A	1810A	1811A	1830A
10001A	X	X	X	L	L		X	X	X	X	X	L	L	L		X					
10001B	X	X	X	L	L		X	X	X	X	X	L	L	L		X					
10002A	X	X	X	L	L		X	X	X	X	X	L	L	L		X					
10002B	X	X	X	L	L		X	X	X	X	X	L	L	L		X					
10003A	X	X	X	L	L		X	X	X	X	X	L	L	L		X					
10004B				X	X							X	X	X			X				
10005B				X	X							X	X	X			X				
10006B				X	X							X	X	X			X				
10007B	X	X	X	L	L	L	X	L	L	X	X	L	L	L	L	X	L	L			L
10008B	X	X	X	L	L	L	X	L	L	X	X	L	L	L	L	X	L	L			L
10012B	X	X	X				X	X	X	X	X					X					
10014A						X									X						
10016A						X									X						
10020A						X									X			X	X	L	X
1120A						X									X			X	L	L	X
1124A						L									L			X	L		L

Notes:
X Indicates that probe will maintain the bandwidth of the instrument.
L Indicates that probe limits the bandwidth of the instrument.

PROBES FOR 50Ω SYSTEMS

100, 250, and 500 MHz active probes

Models 1120A, 1124A, 1125A

500 MHz Active Probe with 1:1 Gain, 1120A
(Measured with output connected to a 50 ohm load.)

Bandwidth (measured from a terminated 50 ohm source): dc-coupled, dc to >500 MHz; ac-coupled, <1.5 kHz to >500 MHz.

Pulse response: (measured from a terminated 50 ohm source) risetime, <0.75 ns; perturbations, <±6% measured with 1 GHz sampler.

Dynamic range: ±0.5 V with ±5 V dc offset.

Noise: approx 1.5 mV (measured tangentially).

Input RC: 100 k ohms, shunt capacitance approx 3 pF at 100 MHz; with 10:1 or 100:1 dividers, shunt capacitance is <1 pF at 100 MHz.

Maximum input: ±100 V.

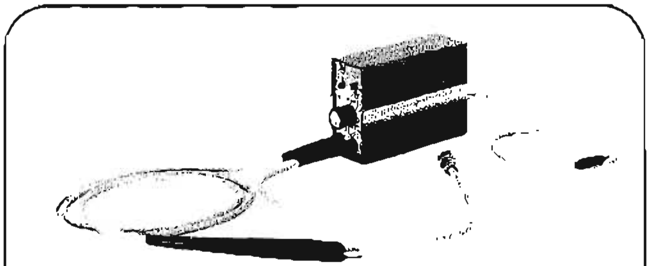
Weight: net, 4 lbs (1,8 kg); shipping, 7 lbs (3,2 kg).

Power: supplied by oscilloscope plug-ins with probe power jacks or a Model 1122A probe power supply.

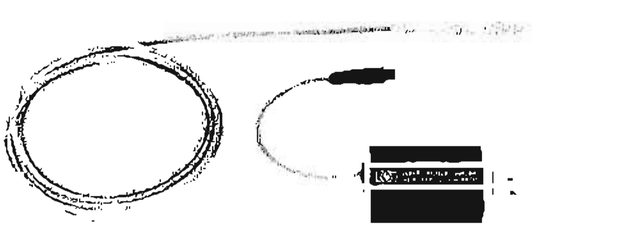
Length: 4 ft over-all; with Option 001, 6 ft.

Accessories furnished
- **Model 10241A 10:1 divider:** increases input R to approx 1 megohm shunted by <1 pF at 100 MHz.
- **Model 10243A 100:1 divider:** increases input R to approx 1 megohm shunted by <1 pF at 100 MHz.
- **Model 10242A bandwidth limiter:** reduces bandwidth to approx 27 MHz shunted by approx 6 pF and reduces gain <2%.
- **Also included:** slip-on hook tip, 2.5" ground lead, spare probe tips, a slip-on BNC probe adapter, two red ID sleeves, and a probe divider adjustment tool (PN 5020-0570).

Price: Model 1120A, $395.
Model 1120A Option 001 approx 6 ft over-all length, add $25.



1120A



1124A

100 MHz Active Probe, 1124A
(Measured when connected to a 50 ohm load.)

Bandwidth (measured from a terminated 50 ohm source): dc-coupled, dc to 100 MHz; ac-coupled, 2 Hz to 100 MHz.

Pulse response (measured from a terminated 50 ohm source): risetime, <3.5 ns; perturbations, 5% p-p. Measured with pulse risetime of >2.5 ns.

Attenuation ratio: 10:1 ±5%; 100:1 ±5%.

Dynamic range: X10, ±10 V; X100, ±100 V.

Input RC: 10 megohms shunted by approx 10 pF.

Maximum safe input
- **DC-coupled:** X10, ±300 V (dc + peak ac) ≤100 MHz; X100, ±500 V (dc + peak ac) ≤100 MHz.
- **AC-coupled:** X10, ±300 V (dc + peak ac) ≤100 MHz. DC component must not exceed ±200 V; X100, ±500 V (dc + peak ac) ≤100 MHz. DC component must not exceed ±200 V.

Accessories supplied: one 8" ground lead, one retractable hook tip, and two probe tip insulating caps.

Power: supplied by 1800 series plug-ins with probe power jacks or Model 1122A probe power supply.

Weight: net, 7 oz (0,20 kg); shipping, 2 lbs (0,91 kg).

Length: approx 5 feet over-all.

Price: HP Model 1124A, $135.

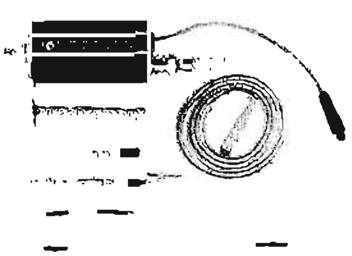
Model 1125A Impedance Converter Probe

Attenuation ratio (oscilloscope gain may be adjusted for 10:1 and 100:1 division ratio): 10.5:1 and 105:1, ±5%.

Dynamic range at probe tip: X10, ±4 V; X100, ±40 V.

Input impedance at probe tip
- **High frequency:** approx 500 ohms (X10) or 5 k ohms (X100) shunted by 0.7 pF (in X10 or X100 modes). (See impedance response graph.)
- **Low frequency:** approx 100 k ohms (dc-coupled). (See impedance response graph.)

NEW▶



1125A

Maximum input
- **All modes:** ±300 V (dc + peak ac) with ±200 V maximum dc component.
- **X10:** dc to 500 Hz, 200 V rms; decreasing 6 dB per octave to 12 V rms at 10 kHz. ≥10 kHz, 12 V rms is maximum allowable continuous input.
- **X100:** dc to 1.5 kHz, 200 V rms; decreasing 6 dB per octave to 35 V rms at 10 kHz. ≥10 kHz, 35 V rms is maximum allowable continuous input.

Bandwidth (with X10 or X100 tip and supplied 4 ft cable).
- **DC-coupled:** dc to 250 MHz.
- **AC-coupled:** 20 Hz to 250 MHz.

Pulse response in X10 or X100: ≤±5% perturbations measured from a terminated 50 ohm source.

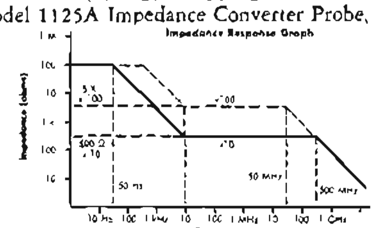
Accessories supplied: one 4 ft 50 ohm cable (10020-61601), one X10 divider tip (10020-67703), one X100 divider tip, (10020-67706), one rigid boot extension (4040-0776), two red color coding sleeves (5040-0477), two clear plastic insulating caps (10020-45401), two jade gray insulating caps (10004-45402), one 2 in. 6-32 ground lead (10020-61602), one 6 in. 6-32 ground lead (10020-61603), one 6-32 alligator tip (5060-0449) and one 6-32 alligator tip (5060-0468).

Power: supplied by instruments with probe power jacks or a Model 1122A probe power supply.

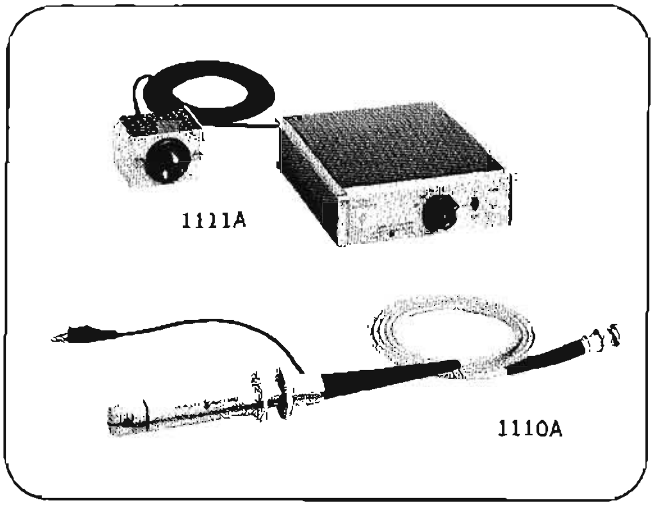
Length: approximate over-all length, 58 in.

Weight: net, 7 oz (0,2 kg); shipping, 2 lb (0,9 kg).

Price: Model 1125A Impedance Converter Probe, $150.



CURRENT PROBE/AMPLIFIER
Probe accessories, power supply
Models 1110A, 1111A, 1122A, 10000 series



1111A AC Current Amplifier
Specifications, 1111A

Deflection factor (with a 50 mV/div oscilloscope deflection factor): in X1, 1 mA/div to 50 mA/div; in X100, 100 mA/div to 5 A/div; 1, 2, 5 sequence in X1 or X100.
Accuracy: in X1, ±3%; in X100, ±4%.
Risetime: 18 ns.
Noise: <100 μA p-p, referenced to input signal.
Maximum ac current: above 700 Hz, 50 A p-p; below 700 Hz, decreases at 1.4 A/20 Hz.
Output impedance: 50 ohms.
Dimensions: 1½" high, 5⅛" wide, 6" deep (38,1; 130,2; 152,4 mm).
Weight: net, approx 2 lb (0,91 kg); shipping, 3 lb (1,36 kg).
Power: 115 or 230 V ±10%, 50 to 400 Hz, 1.5 watts.
Price: Model 1111A Current Amplifier, $225.

1110A Current Probe
Specifications, 1110A

Sensitivity: without 100-ohm termination, 1 mV/mA, with 100-ohm termination, 0.5 mV/mA.
Accuracy: ±3%.
Bandwidth
- **Lower −3 dB point:** without 100-ohm termination, 1700 Hz; with 100-ohm termination, 850 Hz.
- **Upper −3 dB point:** with 4 pF capacitive load, >45 MHz; with 30 pF capacitive load, 35 MHz.

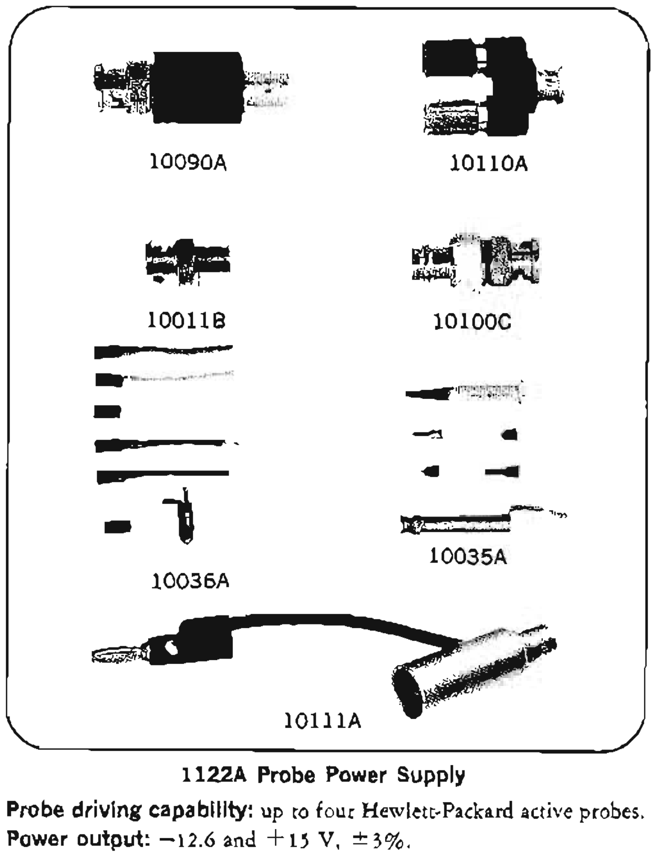
Risetime: with 4 pF capacitive load, 7 ns; with 30 pF capacitive load, 9 ns.
Insertion impedance: approx 0.01 ohm shunted by 1 μH; capacitance to ground <3 pF.
Maximum dc current: 0.5 A.
Maximum ac current: 15 A p-p above 4 kHz; decreasing below 4 kHz at 3.8 A/kHz rate.
Weight: net, 5 oz (0,14 kg); shipping, 2 lb (0,91 kg).
Dimensions: probe aperature, 5/32" diameter; over-all length, 5 ft (1,5 m).
Price: Model 1110A Current Probe, $125.

Probe Accessories
Probe tips

For probes 10001A-10003A: Model 10010C BNC adapter tip, $10.
For probes 10004B-10006B and 100012B: Model 10011B BNC adapter tip.
Price: Model 10011B, $8.

Terminations

Model 10100C, 50 ohm feed-through.
Model 10100B, 100 ohm (±2 ohm) feed-through for 1110A current probe.
Price: Model 10100B, $18; Model 10100C, $15.
Attenuators: Models 10090A (2X, red), 10091A (5X, green), 10092A (10X, black) 50 ohm attenuators provide division accuracies of ±3% from dc to 1 GHz. Power dissipation is 2 watts average with a maximum peak of 3 kilowatts and maximum VSWR is 1.1:1 to 1 GHz.
Price: $25 each.
BNC tip: 10011B for 10004B, 10005B, 10006B probes, $8.
Probe tip kits
Probe tip kits, Models 10036A and 10037A, extend usefulness of 10004B, 10005B, 10006B, and 10012B probes. Model 10036A consists of an assortment including tips for the following: 0.08" jack; 0.025" and 0.045" square pin; 0.040-0.062" dia pin; and a long pin tip. Model 10037A contains six 0.025" square pin tips. Probe tip kit, Model 10035A for 10001A-10003A probes contain pincer jaw, banana tip, pin tip, and spring tip.
Price: Model 10035A, $5; Model 10036A, $20; Model 10037A, $15.



1122A Probe Power Supply

Probe driving capability: up to four Hewlett-Packard active probes.
Power output: −12.6 and +15 V, ±3%.
Power input: 115 V or 230 V ±10%, 48 to 440 Hz, 40 W (with four probes).
Weight: net, 5¼ lbs (2,4 kg); shipping, 8 lbs (3,63 kg).
Accessories supplied: four 10131B 36" extender cables.
Price: HP Model 1122A, $240.

CALIBRATION ACCESSORIES

Time mark generator, extenders

Models 226A, 10000 series

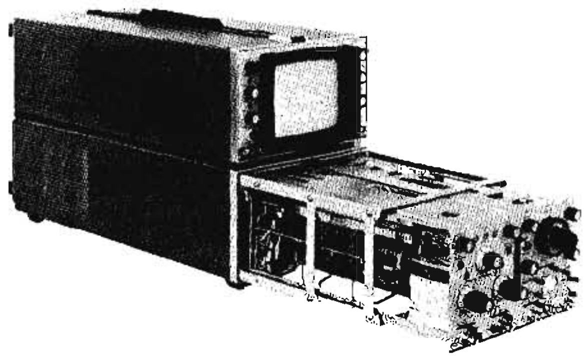
Calibration and service accessories

Plug-in extenders

Plug-in extenders allow calibration and maintenance while a unit is operating.

140 system extender cable Model 10406A (one required for each plug-in), price, $40.

180 system extender (metal frame extends both plug-ins) Model 10407B, price, $95.



104078

182 LVPS Service Extender

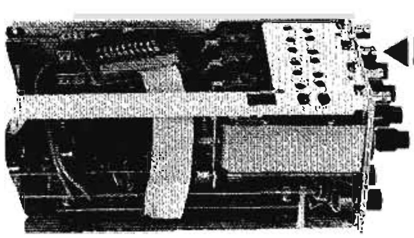
Model 10133A service extender for the 182 oscilloscope allows the power supply to operate out of the mainframe during calibration or trouble shooting.

Price: Model 10133A Service Extender (182), $30.

1804A Extender Board

Model 10412A extender board provides access to the ring counter for fast, easy servicing.

Price: Model 10412A Extender Board (1804A), $20.



◄NEW

10412A

Time mark generator

Model 226A is a high quality, time mark generator that provides 30 precision time intervals for calibrating oscilloscope time bases. Marker intervals are in a convenient 1, 2, 5 sequence that matches the sweep time settings on oscilloscopes. A single, easy-to-read front panel rotary switch provides easy use without confusing nomenclature.

Specifications, 226A

Time mark

Ranges: from 2 ns to 10 s (30 ranges) in 1, 2, 5 sequence.

Output: +1 V peak into 50 ohms. 28 intervals from 10 ns to 10 s. Sine wave output on 2 and 5 ns ranges provides 1 V into 50 ohms.

Accuracy: ±0.005%, 0°C to +55°C; ±0.002% at 25°C after ½ hour warmup.

Trigger frequency: same as time mark to 100 ns, 10 MHz for all ranges faster than 100 ns.

Programming (Optional): all ranges are programmable, requires 6 parallel lines (6 bit word) and 2 timing lines. TTL compatible.

General

Dimensions: 4.5 in high, 7.75 in wide, 8 in deep (114,3: 196,9; 203,2 mm).

Weight: net, 7 lb (3,2 kg); shipping, 9 lb (4,1 kg).

Power: 115 or 230 V ±10%, 48 to 440 Hz; approx 25 watts

Price: Model 226A Time Mark Generator, $670.

Opt 003: for TTL compatible programming, add $150.

226A

Viewing accessories

Viewing hoods

Model 10175A polarizer hood, for use on 5" round CRT bezels, increases contrast and reduces glare when viewing dim traces in ambient light. $15.

Model 10175B viewing hood with removable vinyl face mask for 5" round CRT bezels. $20.

Model 10176A viewing hood for 5" rectangular CRT bezels. $10.

Model 10104A collapsible viewing hood for 1700 series portable oscilloscopes. $12.

Model 10190A light shield for large screen 182 oscilloscope. $6.

10175A 10175B 10176A

Light filters

Model 10178A, metal mesh for 181, 183, 184 oscilloscopes. $15.

Model 10179A, metal mesh (5" rectangular CRT) $7.

Model 10115A blue light filter for 1700 series oscilloscopes. $2.

Amber plastic filter, HP P/N 5020-0530 (5" rectangular CRT). $2.50.

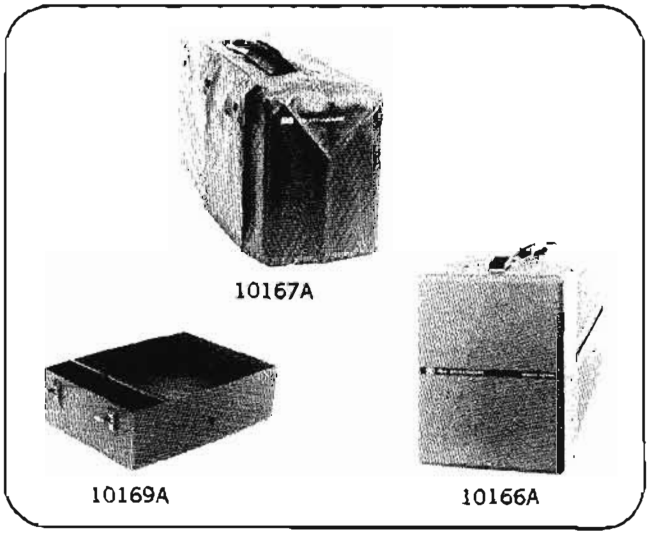
Blue plastic filter, HP P/N 5060-0548 (5" rectangular CRT) $3.

Smoke gray plastic filter, HP P/N 5020-0567 (5" rectangular CRT) $5.

Transit case

A Model 10168A transit case is available for 180, 181, 183, and 184 cabinet style oscilloscopes during transportation and storage. This case provides maximum protection against damage and also provides a seal against dirt and moisture. $230.

PROTECTIVE COVERS
Front panel and oscilloscopes covers, adapters
Model 10000 series



10167A

10169A

10166A

Rack mount slides and adapters

Slides are available for mounting modular and rack style oscilloscopes. A slide adapter is required to secure an oscilloscope to the slides.

120 through 140 series modular oscilloscopes	**prices**
Slide adapter kit: HP P/N 1490-0721	$35.00
Fixed slides: HP P/N 1490-0714	$42.00
Pivot slides: HP P/N 1490-0718	$40.00
180, 181, and 184 rack style oscilloscopes	
Fixed slides, 22-in.: HP P/N 1490-0714	$42.00
Pivot slides, 22-in.: HP P/N 1490-0719	$37.50
183 rack style oscilloscopes	
Pivot slides, 24-in.: HP P/N 1490-0924	$50.00
Slide adapter for 180 series HP P/N 1490-0768	$29.50

Protective covers

Models 10166A and 10169A provide front panel protection and space for probe and accessory storage for 180 series and 1200 series cabinet style oscilloscopes.

Model 10166A for 180 series cabinet oscilloscopes. $30
Model 10169A for 1200 series cabinet oscilloscopes. $35

A rack style metal front panel cover is available to fit 180, 181, 183 or 184 rack model oscilloscopes. Order HP P/N 5060-4037. $60

Flexible covers for 180 series cabinet oscilloscopes provide protection during transportation or storage. A slotted cover top allows access to the scope handle and a pocket on one side is included for accessories.

Model 10167A for 180, 181, or 184 cabinet models $25
Model 10170A for 183 cabinet models $25
Model 10172A for 182 models $30

Flexible covers for 1700 series portable oscilloscopes provide protection during transportation.

Model 10108A for 1700, 1701, 1706, and 1707. $25
Model 10108B for 1702, 1703, 1705, and 1710. $25

Blank plug-ins

Blank plug-ins are available for building special purpose units for 180 and 140 series mainframes.

140 system double size blank plug-in Model 10478A. $35

180 system blank plug-ins
Vertical: Model 10408A, $45.
Horizontal (time base): Model 10409A, $50.
Double size: Model 10410A, $60.

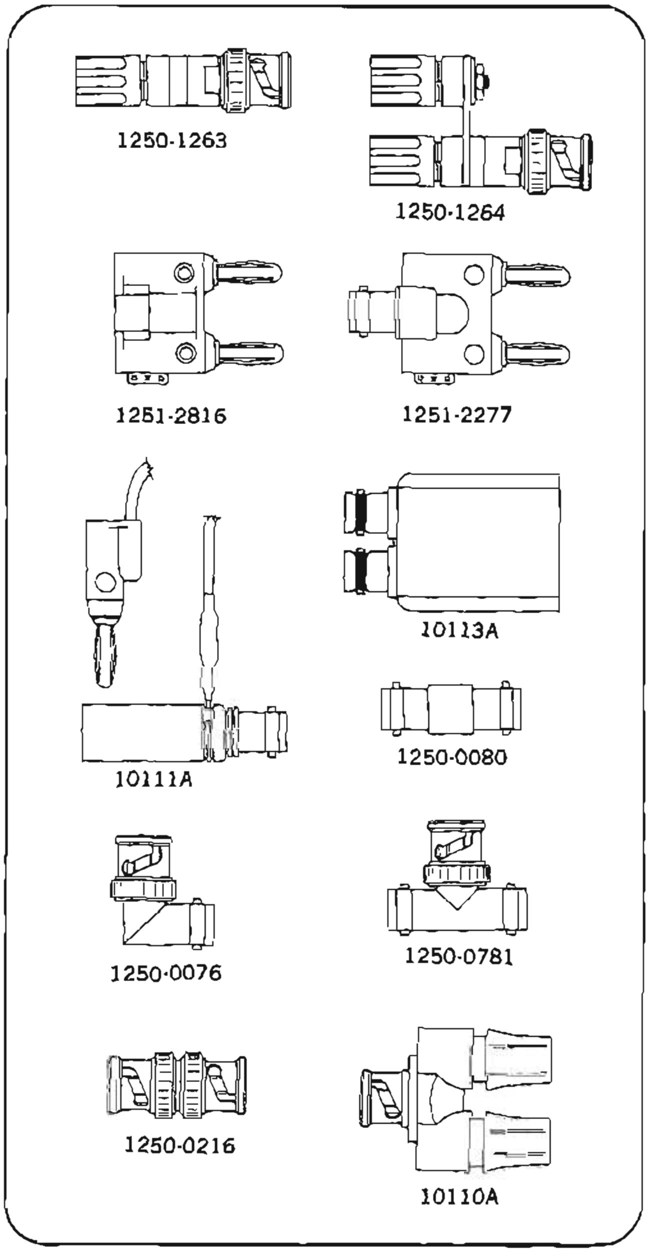
Adapter banana plug

Part No.	Description	Price
1250-1263	Single banana plug to BNC male	$ 7.50
1250-1264	Dual banana plug to BNC male	$13.00
1250-2277	Dual banana plug to BNC female	$ 6.00
1251-2816	Dual banana plug	$ 1.50
Model 10111A	Shielded banana plug to BNC female	$10.00
Model 10113A	Triple banana plug to dual BNC female	$12.00

Adapters BNC

Part No.	Description	Price
1250-0076	Right angle BNC (UG-306/D)	$ 4.00
1250-0080	BNC female to BNC female (UG-914/U)	$ 4.00
1250-0216	BNC male to BNC male	$ 4.00
1250-0781	BNC Tee 1 male, 2 female	$ 5.00
1250-1263	BNC male to single banana plug	$ 7.50
1250-1264	BNC male to dual banana plug	$13.00
1250-2277	BNC female to twin banana plug	$ 6.00
Model 10110A	BNC male to dual binding post	$ 7.00
Model 10111A	BNC female to banana plug (shielded)	$10.00
Model 10113A	Dual BNC female to triple banana plug	$12.00

Refer to page 148 for high frequency adapters and connectors.

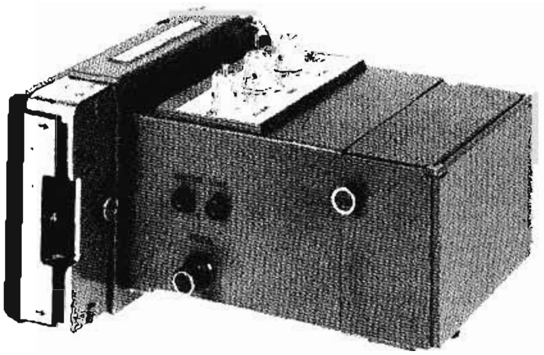


1250-1263 1250-1264 1251-2816 1251-2277 10111A 10113A 1250-0080 1250-0076 1250-0781 1250-0216 10110A

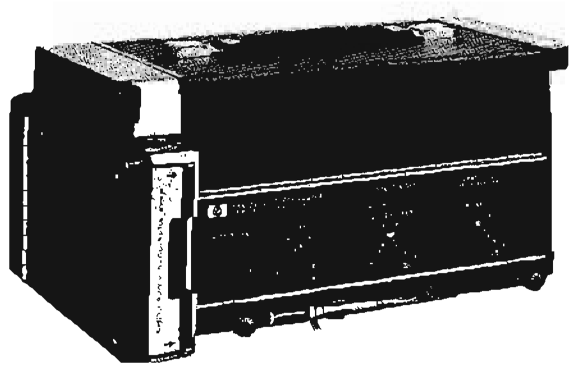
OSCILLOSCOPE CAMERAS

Low cost, easy-to-use, permanent records

Model 123A, 198A



123A



198A

Description, 123A

Model 123A is a lightweight compact camera built for the 1700 series portable oscilloscopes. It can also be used with the HP 180, 182, and other models. The camera does not require external power and only weighs 3½ pounds which makes it ideal for use in field applications. The 123A has a range finder for easy focusing using a split image technique. This range finder also serves as a viewing port so that you can adjust CRT intensity and graticule illumination with the camera in place. Controls are color coded for optimum settings and are located outside of the camera for easy reading and fast adjustment to reduce initial setup time.

The reduction ratio (i.e. object-to-image ratio) may be adjusted from 1:1 to 1:0.65 by simply loosening two screws and sliding the adjusting plate. Synchronization contacts are also provided for use with other equipment.

The 123A mounts directly on 1700 series portable oscilloscopes and will adapt to other oscilloscopes as listed in the compatibility chart.

Specifications, 123A

Reduction ratio: continuously adjustable from 1:1 to 1:0.65.

Lens: 56 mm, f/3.5 lens; aperture ranges f/3.5, f/4, f/5.6, f/8, f/16, and f/22.

Shutter speeds: 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, and 1 seconds Time and Bulb. Cable has thumbscrew lock for time exposures. X-type contacts provided to trigger or synchronize other equipment with shutter release.

Graticule illumination: supplied by the oscilloscope.

Camera back: polaroid land camera that uses Type 107 pack film.

Mounting: lift on/off mounting with positive lock. Mounts directly on HP 1700 series oscilloscopes. Adapters are available to fit other scopes, see Accessories.

Range finder: viewing port provides split image of the CRT to allow setting of the focus.

Viewing: range finder viewing port allows viewing the CRT with camera in position. Camera swings away for wide angle viewing.

Focus: adjustable with camera back closed or open; split image focusing plate provided for use when object-to-image ratio is changed.

Dimensions: 7-9/16 in., 8-13/16 in., 4-13/16 in (192 x 220 x 122 mm).

Weight: net 3½ lb (1,6 kg); shipping, 5 lb (2,3 kg).

Accessories furnished: combination split image focusing plate and reduction ratio scale, and instruction manual.

Price: Model 123A Oscilloscope Camera, $400.

Description, 198A

The HP Model 198A is an economical camera for general-purpose oscilloscope photography. In addition, this camera may be conveniently applied to normal photography of objects or surfaces which can be placed in the camera focal plane.

The camera features a Polaroid® back using the standard flat pack self-processing film, for rapid, on-the-spot results. Graticule (scale) illumination uses a simple pair of mirrors reflecting twin curtains of light onto the surface to be photographed. The mirror system is interlocked with lens focal distance and the mechanical focusing system. When the curtains of light just meet, the CRT graticule is evenly illuminated and the camera is focused.

Graticule illumination can be set continuously on, flashed by the shutter cable-release, or set off. When on or in flash, the illumination intensity is variable. Both focusing and graticule illumination may be seen through a viewing port at the rear of the camera.

Model 198A is easily and directly mounted on any 5-inch Hewlett-Packard oscilloscope by an adjustable clamp that locks the 198A securely in place. Bezel adapters are available for most other oscilloscopes.

Specifications, 198A

Film type: Polaroid® 107 Black and White ASA 3000 8-pack; Polaroid® 108 Color ASA 75 8-pack. (73 x 96 mm). Type 107 (black and white) development time: 15 seconds. Type 108 (color) development time: 60 seconds.

Object-to-image ratio: 1:0.85.

Lens: 75mm. f/3.5.

Shutter

- **Speeds:** B, 1s, ½s, ¼s, ⅛s, 1/15s, 1/30s, 1/60s. Cable release; cable has thumbscrew lock for time exposures.
- **Apertures:** F/3.5, 4, 5.6, 8, 11, 16, 22.

Focus: directly adjustable with camera-back closed or open. Coincidence of vertical light patterns on CRT face indicates correct focus.

Graticule illumination: provided internally. Incandescent lamp and projector/mirror system, with variable intensity control, Off, FLASH, and ON.

Power required: 4 ea Type-C, 1.5 V dry cells (graticule illumination).

OSCILLOSCOPE CAMERA
Electronic timing, general purpose
Models 197A, 195A

Synchronization: X-type contacts provided to trigger or synchronize other equipment with shutter release.
Compatibility
Direct: Hewlett-Packard 5-inch round and rectangular bezels (140, 180, 1200 series oscilloscopes; 8550 series spectrum analyzers, 780 series monitoring oscilloscopes, 8540, 8410 network analyzer, and all other Hewlett-Packard instrumentation having a 5-inch round CRT display.
Adapters for other oscilloscopes: refer to camera bezel adapters.
Dimensions: 7-9/16" x 12-3/16" x 5-13/16" (192 mm x 310 mm x 147 mm).
Weight: net, 6½ lbs (2,95 kg); shipping, 11 lbs (4.99 kg).
Option 001: 1:0.7 object-to-image ratio, allows entire 5-inch round CRT to be photographed, add $65.
Price: Model 198A Oscilloscope Camera, $420.

"Polaroid"® by Polaroid Corp.

Description, 197A

Model 197A is a general purpose oscilloscope camera which can be used for most trace recording applications. All of the 197A controls are conveniently located outside of the camera. Control settings may be read at a glance and quickly changed if desired. Controls are also color-coded for optimum settings for most photos. The electronic shutter provides accurate exposure times from 1/30 to 4 seconds. All solid-state circuits insure reliable operation. The shutter may be operated remotely by providing a closure to ground, and a contact closure is provided when the shutter is open to allow synchronization of other equipment with the camera.

A simple screwdriver adjustment allows the reduction ratio (i.e., the object to image ratio) to be varied from 1:1 to 1:0.7. This allows an optimum amount of the graticule to be photographed, which is useful for making multiple exposures or for different sized CRT's. The camera can be quickly focused using the focus knob and split-image focus plate furnished with the camera.

A technique that enhances the quality of scope photos is available with the 197A camera. A low power ultraviolet (UV) light is used for exposing the black graticule lines in internal graticule CRT's. The UV light causes the CRT phosphor to glow uniformly over its entire surface. The white trace contrasts with the gray background and black graticule lines, making oscillograms taken with this camera easier to interpret.

Specifications, 197A

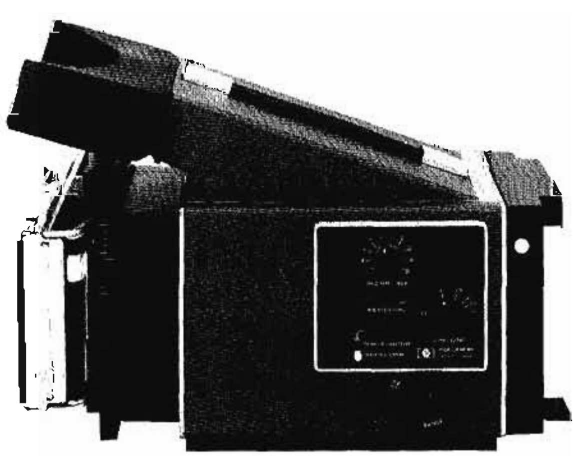
Reduction ratio: continuously adjustable from 1:1 to 1:0.7. Reference scale provided on focus plate.
Lens: 75mm, f/1.9 high transmission lens; aperture ranges f/1.9 to f/16.
Shutter: electronically operated and timed shutter, with all solid-state circuits; shutter speeds are 1/30, 1/15, 1/8, 1/4, 1/2, 1, 2, 4 sec, Time, and Bulb; shutter has a sync contact closure output for triggering external equipment and input jack for remote operation.
Camera back: Polaroid® Land Camera using pack film Type 107 supplied; see options for other backs; backs may be interchanged without refocusing and may be rotated in 90-degree increments.
Mounting: quick lift on-off mounting with positive lock; swing away to left.
Viewing: low-angle, direct viewing flexible face mask.
Multiple exposure: back moves vertically through 11 detented positions at ½ cm per detent at 1:0.9 object-to-image ratio.
Focus: adjustable focusing with lock.
Dimensions: 14" long, 10½" high, 7⅝" wide (356 x 267 x 194 mm) with hood; 12" long, 6½" high, 7⅝" wide (305 x 165 x 194mm) without hood.
Weight: net, 10 lbs (4,5 kg); shipping, 14 lbs (6,4 kg).
Power: 115 V ±10%, 48 to 440 Hz, 6 watts.
Accessories furnished: combination split image focusing plate and reduction ratio scale.
Price: Model 197A Oscilloscope Camera, $675.
Options
001: without ultraviolet light, deduct $50.
003: Graflok® back in place of Polaroid back; no charge.
012: modified for 230 V operation; no charge.
004: Polaroid roll back in place of Polaroid back, no charge.

"Polaroid"® by Polaroid Corp.
"Graflok"® by Graflex, Inc.

Description, 195A

Model 195A is a high speed trace recording camera for photographing high-speed low repetition-rate waveforms. An 80mm, f/1.3 lens with a 2:1 reduction ratio provides high light transmission for high writing speeds.

197A



195A

OSCILLOSCOPE CAMERAS
High speed, single-shot photos
Model 195A

The electronic shutter employed in the 195A provides accurate exposure times from 1/30 to 4 seconds. All solid-state circuits insure reliable operation. The shutter may be operated remotely by producing a closure to ground, and a contact closure is provided when the shutter is open to allow synchronization of other equipment with the camera.

An ultraviolet light option allows a two-fold increase in writing speed by "post-fogging" the film. Ordinarily, a single, faint trace may not expose the film sufficiently to bring the density level above the brightness threshold level. The gray background provided by the UV light, however, moves the trace's "zero" exposure level into the gray region, where a slight increase in exposure, caused by the trace, becomes visible.

The 195A mounts directly to Hewlett-Packard Oscilloscopes with 5-inch round, or rectangular CRTs without requiring a bezel adapter. The 195A will also swing away from the CRT face for easy viewing.

The camera back may be rotated from the normal horizontal position to a vertical position, allowing a 90° rotation of the film format. The back can also be moved through 11 detented positions for multiple exposures. The camera back may also be removed and replaced with a 4 x 5 Graflock® back which allows use of cut or roll film, or a Polaroid® Pack Film back.

Specifications, 195A

Object-to-image ratio: 1:0.5.

Lens: 80mm, f/1.3 high transmission lens; aperature ranges from f/1.3 to f/11.

Shutter: electronically operated and timed shutter, with all solid-state circuits; shutter speeds are 1/30, 1/15, 1/8, 1/4, 1/2, 1, 2, 4 seconds, Time, and Bulb; shutter has a sync contact closure output for triggering external equipment and input jack for remote operation. Shutter-Open Light provides visual indication when shutter is open and shutter speed control is set to: T, B, and all other shutter speeds except 1/15 and 1/30 second.

Camera back: Polaroid® roll film holder standard; Polaroid® pack film holder or Graflok® backs available (see options); backs may be interchanged without refocusing and may be rotated in 90-degree increments.

Mounting: quick lift on-off mounting with positive lock; swing away to left.

Viewing: low-angle, direct viewing flexible face-mask.

Multiple exposure: back moves vertically through 11 detented positions.

Focus adjustable focusing with lock.

Dimensions: 14½" long, 9¾" wide, 10½" high (368 x 248 x 172 mm) without hood.

Weight: net, 12 lbs (5,4 kg); shipping, 18 lbs (8,2 kg).

Power: 115 V ±10%, 48 to 440 Hz.

Accessories furnished: combination split image focusing plate and reduction ratio scale. HP Part No. 1000-0226.

Price: Model 195A Camera, $1025.

Options

001: with ultra violet light, add $50.
002: Graflok® back instead of roll back, no charge.
003: Polaroid® pack back instead of roll back, no charge.
004: modified for 230 V operation, no charge.

"Polaroid"® by Polaroid, Corp.
"Graflok"® by Graflex, Inc.

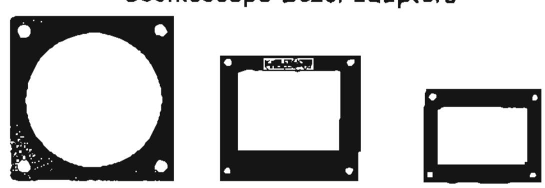
Camera backs

10353A 10365A 10352A

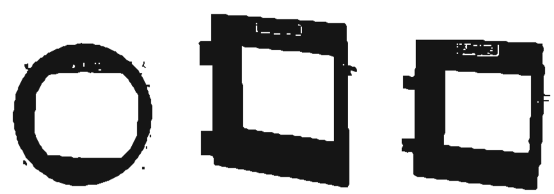
Model 195A is supplied with a Polaroid[1] Roll Film back and Model 197A is supplied with a Polaroid Pack Film back. Either back may be ordered initially as options at no extra charge (refer to specifications), or the backs may be ordered separately. Polaroid Pack Film back, Model 10353A, $95. Polaroid Roll Film back, Model 1036A, $95. Graflok[2] back, Model 10352B, $95.

Note: these backs will not fit on the Model 123A or 198A Cameras.

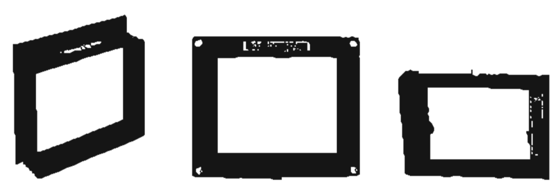
Oscilloscope Bezel adapters



10355A 10356A 10357A



10360A 10361A 10362A



10367A 10363A 10106A

Camera assessories

Model 123A fits HP 1700 series oscilloscopes and 195A, 197A, and 198A fit HP 5-inch rectangular and round CRT oscilloscopes and can be fitted to other oscilloscopes with bezel adapters (see camera/oscilloscope compatibility chart).

Camera bezel adapter prices: Model 10106A, $20; Model 10355A, $20; Model 10356A, $20; Model 10357A, $25; Model 10360A, $20; Model 10361A, $20; Model 10362A, $20; Model 10363A, $20; Model 10366B, $10; Model 10367A, $20. Adapters not shown are: 10369A, 10370A and 10371A, contact your Hewlett-Packard Field Engineer for prices of these adapters.

1 Registered Trademark Poloroid Corporation.
2 Registered Trademark Graflex, Inc.

CAMERA ACCESSORIES

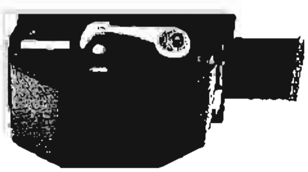
Carrying case

10358B

The Model 10358B carrying case is constructed of fiberglass and aluminum with foam padding to protect the Model 195A, 197A, and 198A cameras in transit or storage. Price: $80.

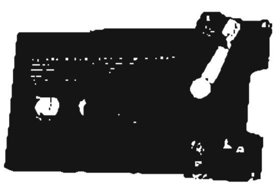
Other accessories

When the 4 x 5 Graflok back is used, various film packs and adapters may be used, some of which are shown below. Order these film packs from the manufacturer or your local camera dealer.



Model RH/50 70mm roll film holder
50 exposures without reloading.
Beattie-Coleman 70mm roll film holder available (type 45R).

Graphic film pack adapter
Daylight load-16-exposure film packs.



Polaroid Land 4 x 5 film holder No. 545
Makes both print and negative in 20 seconds—outside the dark room.

Camera/Oscilloscope Compatibility Chart[1]

OSCILLOSCOPE	CAMERA											
HEWLETT-PACKARD	HEWLETT-PACKARD					TEKTRONIX INC.			DUMONT			
	123A	195A	[4]196A/B	197A	198A	C12	C27	C30/31/32	450A-1	453A-1	450A-7B	321A
5-In. Round CRT	–	Direct	Direct	Direct	Direct	–	–	–	Direct	Direct	Direct	Direct
175A Only	–	Direct	Direct	Direct	Direct	–	–	–	10360A	10360A	10360A	10360A
5-In. Rectangular CRT	10369A	Direct	[3]10360A	Direct	Direct	10361A	10362A	10363A	10360A	10360A	10360A	10360A
182	10370A	10367A	–	10367A	–	–	–	–	–	–	–	–
1330 Series[2]	–	[2]10366B	–	[2]10366B	[2]10366B	–	–	10363A	–	–	–	–
1700 Series	Direct	–	–	–	–	–	–	10106A	–	–	–	–
TEKTRONIX INC.[5]												
5-In. Round 549	–	10355A	10355A	10355A	10355A							
5-In. Rect. & 580 Series	–	10356A	–	10356A	10356A							
529 Series	–	10356A	–	10356A	10356A							
647A	–	10357A	–	10357A	10357A							
422/453/454/485	10371A	–	–	–	–							
DUMONT												
5-In. Round CRT	–	10355A	Direct	10355A	10355A							

Notes

1. This chart only includes HP adapter and camera compatibility, for other combinations contact your Field Engineer.
2. 1330A/1331A serial prefixes 1110A and above and 1331C serial prefix 1116A and above require 10366B adapter.
3. The 10360A adapter hinge mounts interfere with the Find Beam pushbutton on 180 mainframes.
4. Model 196A/B cameras are no longer in production.
5. No adapters are available for mounting HP cameras on Tektronix Inc. 5100 and 7000 series oscilloscopes.

TESTMOBILES
Transport test equipment; save bench space
Models 1119A/B/C/D, 1117B

Description, Models 1119A/B

Models 1119A/B are designed for use with standard 16¾ inch wide Oscilloscopes. When used with scopes such as the 140 series, mounting hardware secures the instrument to the Testmobile. A Model 10479A Tilt-Table is available for the 180 and 1200 series. Typical oscilloscope tilt angle is ±40° in 10° increments.

Specifications, 1119A/B

Oscilloscope compatibility: 120, 130, 140 series direct; 180 and 1200 series with Model 10479A tilt tray; or 180 rack models with mounting plates (P/N 01119-69501).

Tilt angle: ±40° in 10° increments.

Dimensions: see outline drawing.

Wheel size: 4-inches (101,6 mm).

Weight

Model 1119A: net, 34 lb (15,4 kg); shipping, 47 lb (21,3 kg).

Model 1119B: net, 46 lb (20,9 kg); shipping, 63 lb (28,6 kg).

Price

Model 1119A: Testmobile, $115.

Model 1119B: Testmobile (with Model 10480A Storage Cabinet), $155.

Optional accessories

Model 10479A tilt tray: allows oscilloscopes to be placed on Testmobile without direct mounting.

Weight: net, 12 lb (5,4 kg); shipping, 18 lb (8,2 kg).

Price: Model 10479A tilt tray, $35.

Mounting plates: (HP Part No. 01119-69501) adapts 180 series rack model oscilloscopes to Testmobile.

Weight: net, 1 lb (0,5 kg); shipping, 2 lb (0,9 kg).

Price: mounting plates (including detent wheel), $29.10.

Description, 1119C/D

Models 1119C/D are for 180 and 1200 series cabinet style and 1700 series (with a 10105A Adapter) oscilloscopes. Instruments are secured to brace assembly with mounting knobs that mate with matching holes in the scope. Typical tilt angles are ±30° in 10° increments. A tilt-table shelf, Model 10479B allows small instruments to be mounted.

Specifications, 1119C/D

Oscilloscope compatibility: 180 and 1200 series cabinet models, direct, 1700 series with Model 10105A Adapter. When used with optional 10479B Tilt Tray, many other instruments may be placed on the Testmobile.

Tilt angle: ±30° in 10° increments.

Dimensions: see outline drawing.

Wheel size: 4 inches (101.6 mm).

Weight

Model 1119C: net, 32 lb (14,5 kg); shipping, 43 lb (19,5 kg).

Model 1119D: net, 43 lb (19,5 kg); shipping, 54 lb (24,5 kg).

Price

Model 1119C: Testmobile, $110.

Model 1119D: Testmobile (with Model 10480B Storage Cabinet), $145.

Optional accessories

Model 10105A adapter plate: adapts 1700 series oscilloscopes to 1119C and 1119D Testmobiles.

Weight: net, 1 lb (0,5 kg); shipping, 2 lb (0,9 kg).

Price: model 10105A adapter, $15.

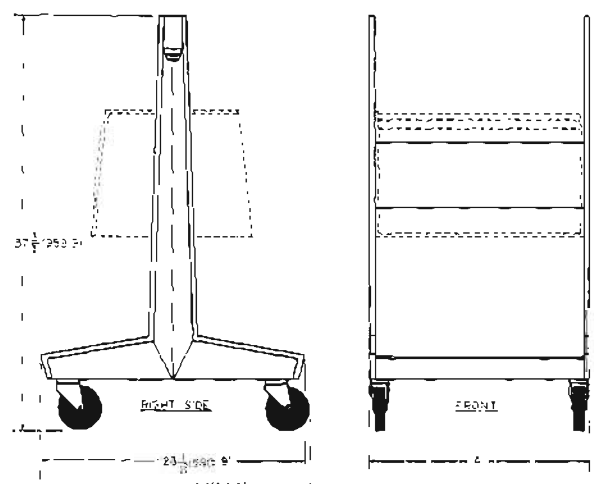
Model 10479B tilt tray: allows oscilloscopes to be placed on Testmobile without direct mounting.

Weight: net, 8 lb (3,6 kg); shipping, 12 lb (5,4 kg).

Price: model 10479B tilt tray, $35.

1119B.

1119C.



Dimension "A"	
1119A/B	19¾"
1119C/D	13¾"

1119A/B/C/D

Description, 1117B

Model 1117B for cabinet and rack instruments provides tilt tray angles from −15° to +30° in 7½° increments. In addition, other instruments can be mounted in the standard relay racks of the lower compartment. Rack mounting depth is 23-inches and power distribution is supplied.

Optional accessory drawers 3″ and 8″ deep are available. The drawers may be installed in many vertical positions of the relay racks.

Specifications, 1117B

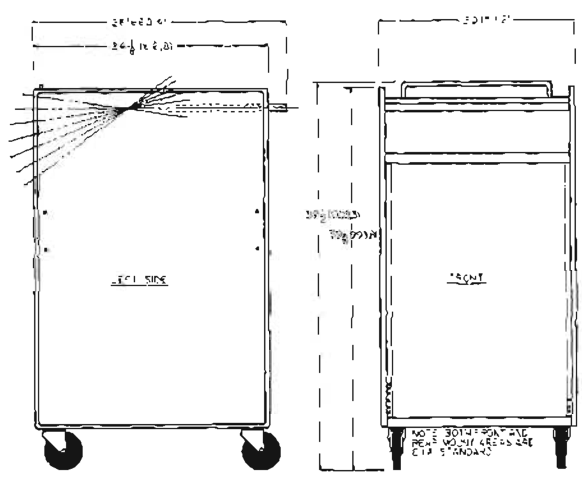
Oscilloscope compatibility: cabinet or 19-inch rack models.

Tilt angle: −15° to +30° in 7½° steps.

TESTMOBILES
Lightweight, compact, folds for transportation
Models 1118A, 1116A

Dimensions: see outline drawing.
Wheel size: 4-inch (101,6 mm).
Weight: net, 91 lb (41,3 kg); shipping, 109 lb (49,4 kg).
Instrument mounting hardware supplied: 8 screws (10-24 x ¾) (HP Part No. 2680-0029), 8 Tinnernan nuts (HP Part No. 0590-0128).
Price (less drawers): model 1117B Testmobile, $240.
Optional accessories
Model 10475A 3-inch drawer
Weight: net, 9 lb (4,1 kg); shipping, 13 lb (5,9 kg).
Price: model 10475A, 3-inch accessory drawer, $40.
Model 10476A 8-inch drawer
Weight: net, 11 lb (5,4 kg); shipping, 18 lb (8,2 kg).
Price: model 10476A, 8-inch accessory drawer, $50.

1117B

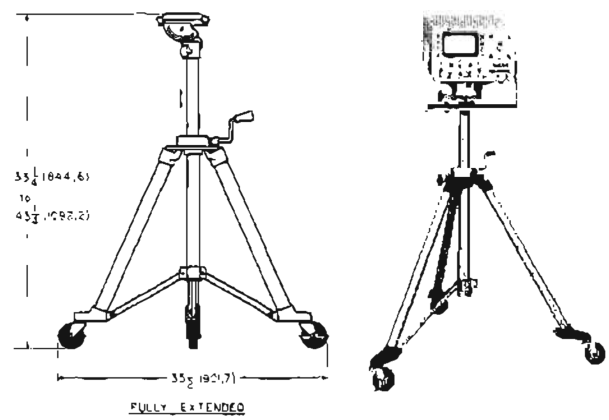


Description, 1118A

Model 1118A Testmobile is designed for 180 or 1200 series cabinet models, and (with a 10105A adapter) 1700 series oscilloscopes. Instruments can be tilted, rotated and vertically adjusted. This tripod testmobile also folds for easy transportation.

Specifications, 1118A

Oscilloscope compatibility: 180 and 1200 series cabinet models direct, 1700 series with 10105A Adapter Plate. (Use Model 1119C or D Testmobile for 183 A or C Oscilloscopes.)
Tilt angle: ±45°.
Horizontal rotation: 360°.
Vertical height: 33 to 43 inches (838,2 to 1117,6 mm).
Dimensions: see outline drawing.
Wheel size: 3-inches (76,2 mm) with locks on two wheels.
Weight: net, 13 lb (5,9 kg); shipping, 17 lb (7,7 kg).
Price: model 1118A, Testmobile, $120.
Optional accessory
Model 10105A adapter plate: adapts 1700 series oscilloscopes to 1118A Testmobiles.
Weight: net, 1 lb (0,5 kg); shipping, 2 lb (0,9 kg).
Price: model 10105A adapter, $15.



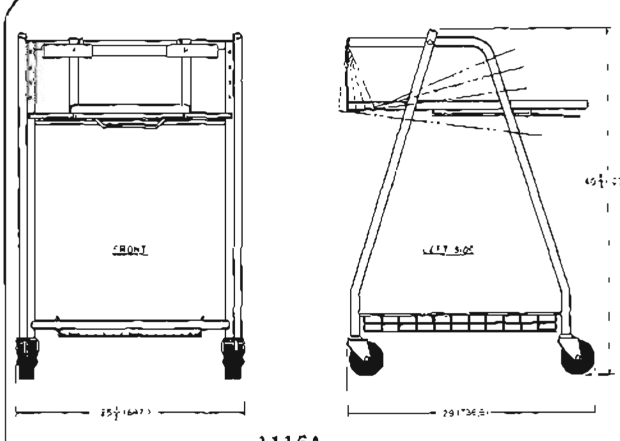
1118A

Description, 1116A

Model 1116A is a light weight Testmobile constructed of chrome-plated tubular steel and is well suited for holding general purpose instrumentation.

Specifications, 1116A

Oscilloscope compatibility: 140 series, 180 series rack models, 1200 series rack models, and other rack width instruments.
Tilt angle: horizontal to 30° in 7½° steps.
Dimensions: see outline drawing.
Wheel size: 4 inches (101,6 mm).
Weight: net, 32 lb (15,5 kg); shipping, 49 lb (22,2 kg).
Price: model 1116A Testmobile, $95.



1116A

GENERAL INFORMATION

Power supplies, as described on the following pages, are defined as instruments which electronically transform ac input power into regulated dc output power. The power supply product information is divided into seven main sections.

(1) General Purpose Lab Supplies: Pgs. 186-193.
(2) Industrial Power Supplies: Pgs. 194 and 195.
(3) Precision Power Supplies: Pgs. 196 and 197.
(4) Modular Power Supplies: Pgs. 204-206.
(5) Bi-polar Power Supply/Amplifiers: Pgs. 198 and 199.
(6) Precision Constant Current Sources: Pg. 200.
(7) Digitally Programmable Power Supplies: Pgs. 202 and 203.

Categories (1) through (4) cover the typical, or general purpose, applications of dc power supplies including general laboratory use, systems power, component testing, reference sources, etc. The bipolar power supply/amplifiers, constant current sources, and digitally programmable supplies have more specialized applications.

All categories are described briefly in subsequent paragraphs on this page and in detail on the pages referenced above. A condensed listing showing model number, output voltage, and output current, of the power supplies in categories (1) through (4) is presented on the adjoining page.

General purpose power supplies

Within this group (general purpose lab, industrial, precision, and modular power supplies) four different classes of specifications are provided: Rating, Performance, Features, and General. The meaning and significance of the most important specifications are described below.

Rating

This specification group covers output voltage (arranged within the specifications tables in ascending voltage order), and output current. The following convention is observed in stating the output current rating: supplies with an adjustable current limit are listed as "O-XXXA"; supplies with a fixed, factory-set current limit are listed as "XXXA."

Performance

Performance information includes all the basic power supply specifications (load and line regulation, ripple and noise, temperature coefficient, stability, and transient response). Definitions of all specifications are given on page 201.

In general, Hewlett-Packard power supplies employ one of three regulation techniques: (1) series-transistor regulation; (2) SCR regulation; or (3) switching-transistor regulation.

All low output power supplies use circuit technique (1) because it results in both lower cost and better performance.

Medium output power lab-type supplies may use either the series or SCR technique; or alternatively, a combination of the two in which a series-transistor regulator is preceded by an SCR regulator. All industrial-type supplies employ circuit technique (2) because of its greater efficiency. The switching-transistor regulator is used in medium and high power modular supplies where compact size, efficiency, and minimum heat generation are of primary importance.

These different regulation techniques result in distinctly different performance characteristics, particularly with regard to regulation, ripple, and transient response.

As a guide line, some typical performance specifications are listed below. Complete specifications are given in the applicable tables.

Specification	Transistor Regulated
Line & Load Regulation	0.001% to 0.05%
Ripple & Noise	50 μV to 1 mV
Transient Response	Less than 50 μs
Specification	**SCR Regulated**
Line & Load Regulation	0.05% to 1%
Ripple & Noise	0.1% to 3%
Transient Response	Less than 50-200 ms
Specification	**Switching Regulated**
Line & Load Regulation	0.05% to 0.2%
Ripple & Noise	20 mV to 60 mV
Transient Response	Less than 5 ms

Features

The features group describes the specific characteristics of various extra-performance features available on most Hewlett-Packard power supplies. Included are:

Output Mode: DC power supplies can provide one of three basic modes of operation: (1) Constant Voltage, where the output voltage is maintained constant in spite of changes in load, line, or temperature; (2) Constant Current, where the output current is maintained constant in spite of changes in load, line, or temperature; (3) Current Limit, where the output current of a constant voltage power supply is limited to a predetermined maximum value (fixed or adjustable).

Auto-Series, Auto-Parallel, and Auto-Tracking: Auto-Series operation is a means of obtaining a higher output voltage than that available from a single supply. Similarly, Auto-Parallel operation is a means of obtaining a higher output current than that available from a single supply. Auto-Series and Auto-Parallel provide equal voltage and current sharing (respectively) under all load conditions; both allow the master supply alone to control the complete ensemble. Auto-Tracking operation is used when several different voltages referred to a common bus must vary in proportion to the setting of a particular supply; it permits simultaneous turn-on and turn-off of power supplies in the same system.

Remote Sensing: Remote sensing is used to maintain good constant voltage load regulation at loads remotely located from the power supply output terminals.

Remote Programming: Most Hewlett-Packard power supplies permit control of the regulated output voltage or current by means of a remotely varied resistance or voltage.

Overvoltage Protection Crowbar: Overvoltage protection circuits provides protection against any overvoltage condition which might occur due to operator error or failure of the power supply or load.

General

Input power ratings and connections, dimensions, weight, price, and options available are given in the specifications tables.

Special purpose power supplies

Power Supply/Amplifiers

Power Supply/Amplifiers (pages 198 and 199) are multi-purpose laboratory instruments capable of operation either as dc power supplies, or as high speed, programmable, bipolar, dc to 20 kHz power amplifiers.

Precision Constant Current Sources

Precision Constant Current Sources (page 200) are designed for applications requiring (1) more precise current regulation, (2) lower ripple and noise at low output current levels, and (3) higher output impedance and faster programming speed (better dynamic characteristics) than are available from a CV/CC supply operating in the constant current mode. Application Note AN-128, available at no charge from your local Hewlett-Packard sales office, provides detailed applications information on Hewlett-Packard Precision Constant Current Sources.

Digital Voltage/Current Sources

Digital Voltage/Current Sources (pages 202 and 203) are designed for applications requiring a computer-controllable high-speed, bipolar, accurately settable source of dc or low frequency ac power. These power supplies are actually complete digital-to-analog subsystems, incorporating input/output isolation, internal digital data storage, flexible interfaces, programmable current latch, computer feedback signals, external analog input, and current monitoring terminals all in one compact package.

Hewlett-Packard offers another means of achieving digitally programmable dc power: The 6940A/6941A Multiprogrammer (page 472), in combination with any of the general purpose power supplies having resistance programming capabilities and employing Option 40. This combination allows control of up to 240 power supplies via a single minicomputer I/O channel, with accuracy of 0.1% and programming speeds from 10 ms.

DC Power Supply Handbook

This 138-page book is a comprehensive source of detailed information on the operation, performance, and connection of all Hewlett-Packard regulated dc power supplies. It is available at no charge from your local Hewlett-Packard sales office.

High power industrial supplies

Model	Ratings Volts	Ratings Amps	Specs Page
6428B	20	45	194
6433B	36	10	194
6434B	40	25	194
6438B	60	5	194
6439B	60	15	194
6443B	120	2.5	194
6448B	600	1.5	194
6453A	15	200	194
6456B	36	100	194
6459A	64	50	194
6464C	8	1000	194
6466C	16	600	194
6469C	36	300	194
6472C	64	150	194
6475C	110	100	194
6477C	220	50	194
6479C	300	35	194
6483C	440	25	194

Precision power supplies

Model	Ratings Volts	Ratings Amps	Specs Page
6101A	20	1	196
6102A	40	0.5	196
6104A	20, 40	2, 1	196
6105A	50, 100	0.4, 0.8	196
6106A	100	200 mA	196
6110A	3000	6 mA	196
6111A	20	1	196
6112A	40	0.5	196
6113A	10	2	196
6114A	20, 40	2, 1	196
6115A	50, 100	0.4, 0.8	196
6116A	100	200 mA	196

General purpose lab supplies

Model	Ratings Volts	Ratings Amps	Specs Page
712C	−150, −300, 500,	5 mA; 50 mA; 200 mA	198
721A	30	0.15	188
890A	320	0.6	192
895A	320	1.5	192
6200B	20	1.5	186
6200B	40	0.75	188
6201B	20	1.5	186
6202B	40	0.75	188
6203B	7.5	3	186
6204B	20	0.6	186
6204B	40	0.3	188
6205B	20	0.6	186
6205B	40	0.3	188
6206B	30	1	186
6206B	60	0.5	188
6207B	160	0.2	192
6209B	320	0.1	192
6211A	100	100 mA	192
6212A	100	100 mA	192
6213A	10	1	186
6214A	10	1	186
6215A	25	400 mA	188
6216A	25	400 mA	188
6217A	50	0.2	190
6218A	50	0.2	190
6220B	25	1	186
6220B	50	0.5	188
6224B	24	3	188
6226B	50	1.5	190
6227B	25	2	188
6228B	50	1	190
6253A	20	3	186
6255A	40	1.5	190
6256B	10	20	186
6259B	10	50	186
6260B	10	100	186
6261B	20	50	188
6263B	20	10	188
6264B	20	20	188
6265B	40	3	190
6266B	40	5	190
6267B	40	10	190
6268B	40	30	190
6269B	40	50	190
6271B	60	3	192
6274B	60	15	192
6281A	7.5	5	186
6282A	10	10	186
6284A	20	3	186
6285A	20	5	186
6286A	20	10	188
6289A	40	1.5	190
6290A	40	3	190
6291A	40	5	190
6294A	60	1	190
6296A	60	3	192
6299A	100	750 mA	192
6384A	5.5	8	186
6515A	1600	5 mA	192
6516A	3000	6 mA	192
6521A	1000	200 mA	192
6522A	2000	100 mA	192
6525A	4000	50 mA	192

Modular power supplies

62000 Series (see page 204)
44 Models/3-48 V/To 192 W Output
Series Regulated

Model	Volts	Amps "A" MOD	Amps "C" MOD	Amps "E" MOD	Amps "G" MOD
62003	3	2.0	4.25	8.5	17.0
62004	4	2.0	4.0	8.0	16.0
62005	5	2.0	4.0	8.0	16.0
62006	6	1.75	3.75	7.5	15.0
62010	10	1.5	3.25	6.5	13.0
62012	12	1.5	3.0	6.0	12.0
62015	15	1.25	2.5	5.0	10.0
62018	18	1.0	2.25	4.5	9.0
62024	24	0.75	1.75	3.75	7.5
62028	28	0.70	1.5	3.25	6.5
62048	48	0.45	1.0	2.0	4.0

62600 Series (see page 205)
9 Models/4-28 V/To 300 W Output
Switching Regulated

Model	Ratings Volts	Ratings Amps	Efficiency %
62604J	4 V	40.0 A	65
62605J	5 V	40.0 A	65
62606J	6 V	33.0 A	65
62610J	10 V	25.0 A	75
62612J	12 V	23.0 A	75
62615J	15 V	20.0 A	80
62618J	18 V	16.7 A	80
62624J	24 V	12.5 A	80
62628J	28 V	10.7 A	80

60,000 Series (see page 206)
6, 12, 24 V and ±15 V/Single and Dual Outputs
Series Regulated

Model		Ratings Nominal Volts	Ratings Amps
60063A	Single	6	1.5
60065A	Single	6	3
60066A	Single	6	8
60122B	Single	12	0.5
60123B	Single	12	1
60125B	Single	12	2.2
60126B	Single	12	6
60242B	Single	24	0.25
60243B	Single	24	0.5
60244B	Single	24	1
60245B	Single	24	1.5
60246B	Single	24	3.5
60153D	Dual	±15	0–0.2
60155C	Dual	±15	0–0.75

GENERAL PURPOSE LAB SUPPLIES
Single & Dual Outputs, 8-2,000 Watts
Models 721A, 890A, 895A, 6200B 6384A, 6515A-6525A

Low cost single output supplies

Description

Models 6211A-6218A. These low cost, compact, and reliable power supplies are designed especially for bench use. Their performance and features make them ideal for circuit development, component evaluation, and other general laboratory applications. The units are packaged in a molded impact-resistant case with an interlocking feature that allows two or more supplies to be stacked vertically. Standard features include short-circuit protection, dual-function metering, and coarse and fine output voltage controls. Any number of supplies can be connected in series when greater voltage is desired. Rack mounting accessories are described on page 201.

Model 721A. The 721A is a low cost bench-type power supply, packaged in a rugged aluminum case. The supply will current-limit at any of four switch-selected values (25, 50, 100, or 200 mA), while a six-position meter switch selects either of two voltage ranges (10 or 30 V) or four current ranges (10, 30, 100, or 300 mA) for display on the meter. Performance and features of this supply make it especially useful for transistor circuit development applications.

Models 6200B-6209B (except 6205B). These models are packaged in 8-inch wide cases which are suitable for bench use or rack installation. Rack mounting accessories are described on page 201. Standard features include Constant Voltage/Constant Current or Constant Voltage/Current Limit operation (depending on model), remote resistance and voltage programming, remote sensing, Auto-Series/Auto-Parallel/Auto-Tracking operation, and dual-function multi-range metering.

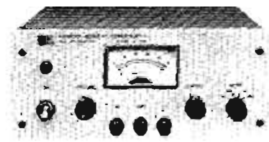
Selection Guide (General Purpose Lab Supplies)

Rating Volts	Rating Amps	Model	Load Regulation Voltage	Load Regulation Current	Line Regulation Voltage	Line Regulation Current	Ripple & Noise Voltage rms	Ripple & Noise Voltage p-p	Ripple & Noise Current rms	Ripple & Noise Current p-p	Temperature Coefficient Voltage	Temperature Coefficient Current	Output Mode
4-5.5	8	6384A	1mV	NA	1mV	NA	1mV	5mV	NA	NA	3mV	NA	CV/CL
0-7.5	0-3	6203B	5mV	0.03% plus 250μA	3mV	0.01% plus 250μA	200μV	1mV	500μA	—	0.02% plus 1mV	0.02% plus 2mA	CV/CC
0-7.5	0-5	6281A	5mV	0.01% plus 250μA	0.01% plus 2mV	0.01% plus 250μA	200μV	1mV	4mA	—	0.02% plus 500μV	0.02% plus 2.5mA	CV/CC
0-10	1	6213A	4mV	NA	4mV	NA	200μV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-10	0-1	6214A	4mV	500μA	4mV	750μA	200μV	1mV	150μA	500μA	0.02% plus 1mV	6mA	CV/CC
0-10	0-10	6282A	0.01% plus 1mV	0.05% plus 1mA	0.01% plus 1mV	0.05% plus 1mA	500μV	25mV	5mA	—	0.02% plus 500μV	0.02% plus 5mA	CV/CC
0-10	0-20	6256B	0.01% plus 200μV	0.02% plus 500μA	0.01% plus 200μV	0.02% plus 500μA	200μV	10mV	5mA	—	0.01% plus 200μV	0.01% plus 2mA	CV/CC
0-10	0-50	6259B	0.01% plus 200μV	0.02% plus 1mA	0.01% plus 200μV	0.02% plus 2mA	500μV	5mV	25mA	—	0.01% plus 200μV	0.01% plus 4mA	CV/CC
0-10	0-100	6260B	0.01% plus 200μV	0.02% plus 2mA	0.01% plus 200μV	0.02% plus 2mA	500μV	5mV	50mA	—	0.01% plus 200μV	0.01% plus 8mA	CV/CC
0-20 0-40	0.6 0.3	6204B	0.01% plus 4mV	NA	0.01% plus 4mV	NA	200μV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-20 0-40 Dual	0.6 0.3	6205B	0.01% plus 4mV	NA	0.01% plus 4mV	NA	200μV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-20 0-40	0-1.5 0-0.75	6200B	0.01% plus 4mV	0.03% plus 250μA	0.01% plus 4mV	0.01% plus 250μA	200μV	1mV	500μA	—	0.02% plus 1mV	0.02% plus 1mA	CV/CC
0-20	0-1.5	6201B	0.01% plus 4mV	0.03% plus 250μA	0.01% plus 4mV	0.01% plus 250μA	200μV	1mV	500μA	—	0.02% plus 1mV	0.02% plus 1mA	CV/CC
0-20 Dual	0-3	6253A	0.01% plus 4mV	0.01% plus 250μA	0.02% plus 2mV	0.01% plus 250μA	200μV	1mV	2mA	—	0.02% plus 500μV	0.02% plus 1.5mA	CV/CC
0-20	0-3	6284A	0.01% plus 4mV	0.01% plus 250μA	0.01% plus 2mV	0.01% plus 250μA	200μV	1mV	2mA	—	0.02% plus 500μV	0.02% plus 1.5mA	CV/CC
0-20	0-5	6285A	0.01% plus 1mV	0.05% plus 1mA	0.01% plus 1mV	0.05% plus 1mA	500μV	25mV	3mA	—	0.02% plus 500μV	0.02% plus 2.5mA	CV/CC

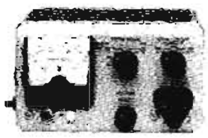
— — indicates that information was not available at time of printing; NA indicates Not Applicable; DUAL indicates supply has two, independent, dc output voltages.

Low cost single output supplies

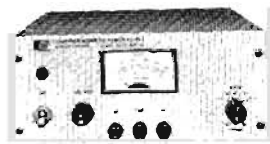
6211A—}
6212A—} 100V/0.1A; p. 192
6213A—}
6214A—} 10V/1A; p. 186
6215A—}
6216A—} 25V/0.4A; p. 188
6217A—}
6218A—} 50V/0.2A; p. 190



6200B—200V/1.5A or 40V/0.75A; p. 186
6204B—20V/0.6A or 40V/0.3A; p. 186
6206B—60V/0.5A or 30V/1A; p. 190



721A—30V/0.15A; p. 188

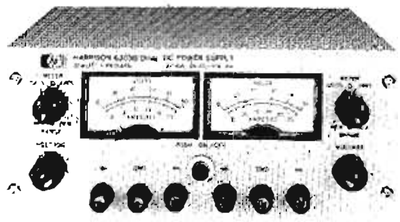


6201B—20V/1.5A; p. 186
6202B—40V/0.75A; p. 188
6203B—7.5V/3A; p. 186
6207B—160V/0.2A; p. 192
6209B—320V/0.1A; p. 192

Stability		Transient Recovery		Series Par. Track.	Remote Prog.	Overvoltage Protection		Input Power	Dimensions (in./mm)			Options Available (page 201)	Price
Voltage	Current	Time	Level			Option	Price		W	H	D		
0.3% plus 10mV	NA	50μs	10mV	No	No	Standard	NC	115Vac ±10%, 48-63Hz, 1.4A, 120W	8½ 216	3½ 89	12½ 317	28	$250
0.1% plus 5mV	0.1% plus 10mA	50μs	10mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 0.9A, 70W	8½ 216	3½ 89	12½ 317	7,8,9,11 13, 14, 28	$190
0.1% plus 2.5mV	0.1% plus 12.5mA	50μs	15mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 1.3A, 118W	8½ 216	3½ 89	14½ 368	7,8,9,11 13,14,28	$245
0.1% plus 5mV	NA	50μs	15mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 0.29A, 28W	5¼ 133	3¼ 83	8 203	28	$99
0.1% plus 5mV	15mA	50μs	15mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 0.3A, 28W	5¼ 133	3¼ 83	8 203	28	$120
0.1% plus 2.5mV	0.1% plus 25mA	50μs	15mV	Yes	Yes	11	$55	115Vac ±10%, 57-63Hz, 3.5A, 200W	8½ 216	5¼ 133	16 406	5,7,8,9,11 13,14,18	$360
0.03% plus 500μV	0.03% plus 6mA	50μs	10mV	Yes	Yes	Standard	NC	115Vac ±10%, 57-63Hz, 5A, 375W	19 483	5¼ 133	17½ 445	5,7,8,9,10,13,14 20,21,22,27,28,40	$525
0.03% plus 2mV	0.03% plus 10mA	50μs	10mV	Yes	Yes	Standard	NC	230Vac ±10%, 57-63Hz, 6A, 850W	19 483	7 178	17½ 445	5,7,8,9,10,13,14 20,21,22,26,27,40	$725
0.03% plus 2mV	0.03% plus 20mA	50μs	10mV	Yes	Yes	Standard	NC	230Vac ±10%, 57-63Hz, 12A, 1600W	19 483	7 178	17½ 445	5,7,8,9,10,13,14 16,20,21,22,27,40	$895
0.1% plus 5mV	NA	50μs	10mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 0.4A, 24W	8½ 216	3½ 89	12½ 317	7,11,13,28	$170
0.1% plus 5mV	NA	50μs	10mV	Yes	Yes	11	$90	115Vac ±10%, 48-440Hz, 0.5A, 50W	8½ 216	3½ 89	12½ 317	7,11,13,28,40	$255
0.1% plus 5mV	0.1% plus 5mA	50μs	10mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 0.9A, 70W	8½ 216	3½ 89	12½ 317	7,8,9,11,13,14 28	$210
0.1% plus 5mV	0.1% plus 5mA	50μs	10mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 0.8A, 66W	8½ 216	3½ 89	12½ 317	7,8,9,11,13,14 28	$190
0.1% plus 2.5mV	0.1% plus 7.5mA	50μs	15mV	Yes	Yes	11	$110	115Vac ±10%, 48-440Hz, 2.6A, 235W	19 483	3½ 89	14½ 368	7,8,9,10,11,13 14,28	$490
0.1% plus 2.5mV	0.1% plus 7.5mA	50μs	15mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 1.5A, 128W	8½ 216	3½ 89	14½ 368	7,8,9,11,13,14 28	$230
0.1% plus 2.5mV	0.1% plus 12.5mA	50μs	15mV	Yes	Yes	11	$55	115Vac ±10%, 57-63Hz, 3.5A, 160W	8½ 216	5¼ 133	16 406	5,7,8,9,11,13,14 18	$350

— Indicates that information was not available at time of printing; NA indicates Not Applicable; NC indicates No Charge

Low cost dual output supply



62058—20V/0.6A or 40V/0.3A; p. 186

Description

Model 6205B. The Model 6205B is actually two independent Constant Voltage/Current Limit power supplies in a single half-rack width case. Each regulated output is selectable in either of two ranges (0-20 V at 0-0.6 A or 0-40 V at 0-0.3 A) by a convenient front-panel switch. Output voltage is adjusted by concentric coarse and fine controls. Separate controls, binding posts, and dual-function meters are provided for each output. Automatic current limiting, remote sensing, remote voltage and current output programming, and Auto-Series/Auto-Parallel/Auto-Tracking operation are standard features. For protection of delicate loads, built-in overvoltage crowbar protection is available as an option. Units measure 8-7/32" W x 3-13/32" H x 11¾" D and may be bench operated or mounted individually, in pairs, or combined with models 6200B-6209B using optional rack-mounting kits (see page 201).

Selection Guide (General Purpose Lab Supplies) continued

Rating		Model	Load Regulation		Line Regulation		Ripple & Noise				Temperature Coefficient		Output Mode
Volts	Amps		Voltage	Current	Voltage	Current	Voltage rms	Voltage p-p	Current rms	Current p-p	Voltage	Current	
0-20	0-10	6286A	0.01% plus 1mV	0.05% plus 1mA	0.01% plus 1mV	0.05% plus 1mA	500μV	25mV	5mA	—	0.02% plus 500μV	0.02% plus 5mA	CV/CC
0-20	0-10	6263B	0.01% plus 200μV	0.02% plus 500μA	0.01% plus 200μV	0.02% plus 500μA	200μV	10mV	3mA	--	0.01% plus 200μV	0.01% plus 2mA	CV/CC
0-20	0-20	6264B	0.01% plus 200μV	0.02% plus 500μA	0.01% plus 200μV	0.02% plus 600μA	200μV	10mV	5mA	--	0.01% plus 200μV	0.01% plus 2mA	CV/CC
0-20	0-50	6261B	0.01% plus 200μV	0.02% plus 1mA	0.01% plus 200μV	0.02% plus 1mA	500μV	5mV	25mA	--	0.01% plus 200μV	0.01% plus 4mA	CV/CC
0-24	0-3	6224B	0.01% plus 4mV	0.01% plus 250μA	0.01% plus 2mV	0.01% plus 250μA	200μV	1mV	200μA	1mA	0.02% plus 600μV	0.02% plus 1.5mA	CV/CC
0-25	400mA	6215A	4mV	NA	4mV	NA	200μV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-25	0-400mA	6218A	4mV	500μA	4mV	500μA	200μV	1mV	150μA	500μA	0.02% plus 1mV	2mA	CV/CC
0-25 0-50	0-1 0-0.5	6220B	0.01% plus 2mV	0.01% plus 250μA	0.01% plus 2mV	0.01% plus 250μA	200μV	1mV	200μA	1mA	0.02% plus 1mV	0.02% plus 1mA	CV/CC
0-25 Dual	0-2	6227B	0.01% plus 1mV	0.01% plus 250μA	1mV	100μA	250μV	4mV	250μA	2mA	0.02% plus 200μV	0.02% plus 300μA	CV/CC
0-30	150mA	721A	0.3% or 30mV	NA	0.3% or 15mV	NA	150μV		NA	NA	—	NA	CV/CL
0-30 0-60	1 0.5	6206B	0.01% plus 4mV	NA	0.01% plus 4mV	NA	200μV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-40 0-20	0.3 0.6	6204B	0.01% plus 4mV	NA	0.01% plus 4mV	NA	200μV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-40 0-20 Dual	0.3 0.6	6205B	0.01% plus 4mV	NA	0.01% plus 4mV	NA	200μV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-40 0-20	0-0.75 0-1.5	6200B	0.01% plus 4mV	0.03% plus 250μA	0.01% plus 4mV	0.01% plus 250μA	200μV	1mV	500μA	--	0.02% plus 1mV	0.02% plus 1mA	CV/CC
0-40	0-0.75	6202B	0.01% plus 4mV	0.03% plus 250μA	0.01% plus 4mV	0.01% plus 250μA	200μV	1mV	500μA	--	0.02% plus 1mV	0.02% plus 0.5mA	CV/CC

-- indicates that information was not available at time of printing; NA indicates Not Applicable; DUAL indicates supply has two, independent, dc output voltages.

General purpose single output supplies

Description

This group of regulated power supplies consists of five series covering thirty different models. The five series are designated: (1) Low Voltage Rack Supplies; (2) Medium Power Rack Supplies; (3) Medium Power Bench Supplies; (4) Compact Bench Supplies; and (5) *Integrated Circuit Bench Supply*. Photographs of these supplies are given on pages 190 and 191. Rack mounting accessories are described on page 201.

Low Voltage Rack Supplies, Models 6256B-6274B. This series consists of thirteen full-rack width models packaged in three different height cases. All models are of the Constant Voltage/Constant Current type. Available output ratings range from 0-10 V at 0-20 A to 0-60 V at 0-15 A. Standard features include overvoltage crowbar protection, remote sensing, and remote resistance and voltage programming.

Medium Power Rack Supplies, Models 890A and 895A. These solid state general purpose Constant Voltage/Current Limit type supplies provide continuously variable output voltage in the range of 0-320 V. Model 890A has a 0-600 mA output, while the 895A is rated at 0-1.5 A. High performance specifications include 0.007% line and load regulation and 1 mV rms ripple and noise. Remote sensing and programming are standard features. Units are packaged in full-rack width modules measuring either 3½ inches high (890A) or 5¼ inches high (895A).

Medium Power Bench Supplies, Models 6281A-6299A. Eleven regulated power supplies in two different size packages make up this group of bench-type supplies. All models are of the Constant Voltage/Constant Current type, with remote sensing, remote programming, and Auto-Series/Auto-Parallel/Auto-Tracking operation as standard features. Output voltage and current are adjusted by means of concentric coarse and fine controls. A four-position meter switch selects either of two voltage or current ranges for display on the dual-function panel meter. Dual-output versions of models 6284A and 6289A are available (models 6253A and 6255A) as described on page 192.

Compact Bench Supplies, Models 6220B, 6224B and 6226B. This series consists of three Constant Voltage/Constant Current dc power supplies suitable for either bench or rack use. Model 6220B is a dual-range instrument with output ratings of 0-25 V at 0-1 A or 0-50 V at 0-0.5 A. Models 6224B and 6226B have single outputs of 0-24 V at 0-3 A and 0-50 V at 0-1.5 A, respectively. All models feature ten-turn voltage and current controls and multi-range dual-function metering. Remote sensing, remote programming, and Auto-Series/Auto-Parallel/Auto-Tracking operation are standard on all models.

Integrated Circuit Bench Supply, Model 6384A. The 6384A is a well-regulated Constant Voltage/Current Limit supply. Its output rating of 4.5-6 V at 0-10 A, low ripple and noise (5 mV p-p) and fast transient response (50 us) make it an ideal supply for integrated circuit and other low voltage semiconductor circuit applications. Included is an over-voltage crowbar circuit for protection of sensitive loads.

Stability		Transient Recovery		Series Par. Track.	Remote Prog.	Overvoltage Protection		Input Power	Dimensions (in./mm)			Options Available (page 201)	Price
Voltage	Current	Time	Level			Option	Price		W	H	D		
0.1% plus 2.5mV	0.1% plus 25mA	50μs	15mV	Yes	Yes	11	$55	115Vac ±10%, 57-63Hz, 5.5A, 320W	8½ 216	5¼ 133	16 406	5,7,8,9,11,13,14 18	$395
0.03% plus 500μV	0.03% plus 5mA	50μs	10mV	Yes	Yes	Standard	NC	115Vac ±10%, 57-63Hz, 4A, 350W	19 483	3½ 89	17½ 445	5,7,8,9,10,13,14 20,21,22,27,28,40	$485
0.03% plus 500μV	0.03% plus 6mA	50μs	10mV	Yes	Yes	Standard	NC	115Vac ±10%, 57-63Hz, 8A, 600W	19 483	5¼ 133	17½ 445	5,7,8,9,10,13,14 20,21,22,27,28,40	$550
0.03% plus 2mV	0.03% plus 10mA	50μs	10mV	Yes	Yes	Standard	NC	230Vac ±10%, 57-63Hz, 12A, 1500W	19 483	7 178	17½ 445	5,7,8,9,10,13,14 20,21,22,26,27,40	$855
0.1% plus 2.5mV	0.1% plus 7.5mA	50μs	10mV	Yes	Yes	NA	NA	115Vac ±10%, 48-63Hz, 1.8A, 164W	5⅛ 130	6¼ 159	11 279	13,14,28,40	$355
0.1% plus 5mV	NA	50μs	15mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 0.26A, 25W	5¼ 133	3¼ 83	8 203	28	$99
0.1% plus 5mV	5mA	50μs	15mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 0.25A, 26W	5¼ 133	3¼ 83	8 203	28	$120
0.1% plus 5mV	0.1% plus 5mA	50μs	10mV	Yes	Yes	NA	NA	115Vac ±10%, 48-440Hz, 0.5A, 44W	5⅛ 130	6¼ 159	11 279	13,14,28,40	$295
0.2% plus 2mV	0.2% plus 3mA	50μs	10mV	Yes	Yes	Standard	NC	115 or 230Vac±10% 48-63Hz,2.7A,260W	7¾ 197	6⅛ 156	12⅜ 315	7,8,9,13,14	$525
--	NA	--	--	No	No	NA	NA	115 or 230Vac ±10%, 48-63Hz, 16W	7 178	4⅜ 111	5¼ 133	NA	$165
0.1% plus 5mV	NA	50μs	10mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 1A, 66W	8½ 216	3½ 89	12½ 317	7,11,13,28	$180
0.1% plus 5mV	NA	50μs	10mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 0.4A, 24W	8½ 216	3½ 89	12½ 317	7,11,13,28	$170
0.1% plus 5mV	NA	50μs	10mV	Yes	Yes	11	$90	115Vac ±10%, 48-440Hz, 0.5A, 50W	8½ 216	3½ 89	12½ 317	7,11,13,28	$255
0.1% plus 5mV	0.1% plus 5mA	50μs	10mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 0.9A, 70W	8½ 216	3½ 89	12½ 317	7,8,9,11,13,14 28	$210
0.1% plus 5mV	0.1% plus 2.5mA	50μs	10mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 0.8A, 85W	8½ 216	3½ 89	12½ 317	7,8,9,11,13,14 28	$190

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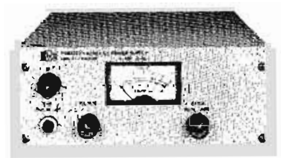
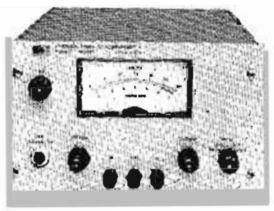
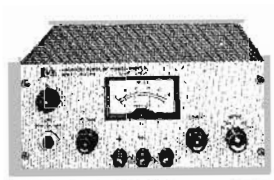
General purpose single output supplies



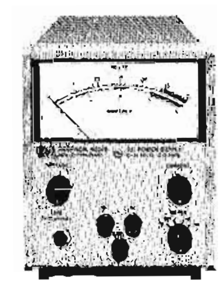
6384A—5.5V/8A; p. 186



6282A—10V/10A; p. 186
6285A—20V/5A; p. 186
6286A—20V/10A; p. 188
6290A—40V/3A; p. 190
6291A—40V/5A; p. 190
6296A—60V/3A; p. 192



6281A—7.5V/5A; p. 186
6284A—20V/3A; p. 186
6289A—40V/1.5A; p. 190
6294A—60V/1A; p. 190
6299A—100V/0.75A; p. 192



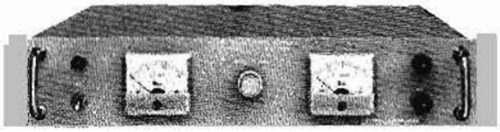
6220B—25V/1A or 50V/0.5A; p. 188
6224B—24V/3A; p. 188
6226B—50V/1.5A; p. 190

Selection Guide (General Purpose Lab Supplies) continued

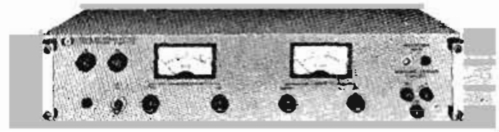
Rating Volts	Rating Amps	Model	Load Regulation Voltage	Load Regulation Current	Line Regulation Voltage	Line Regulation Current	Ripple & Noise Voltage rms	Ripple & Noise Voltage p-p	Ripple & Noise Current rms	Ripple & Noise Current p-p	Temperature Coefficient Voltage	Temperature Coefficient Current	Output Mode
0-40	0-1.5	6289A	0.01% plus 2mV	0.01% plus 250µA	0.01% plus 2mV	0.01% plus 250µA	200µV	1mV	500µA	—	0.02% plus 500µV	0.02% plus 0.8mA	CV/CC
0-40 Dual	0-1.5	6255A	0.01% plus 2mV	0.01% plus 250µA	0.01% plus 2mV	0.01% plus 250µA	200µV	1mV	500µA	--	0.02% plus 500µV	0.02% plus 0.8mA	CV/CC
0-40	0-3	6290A	0.01% plus 1mV	0.05% plus 1mA	0.01% plus 1mV	0.06% plus 1mA	500µV	25mV	3mA	—	0.02% plus 500µV	0.02% plus 1.5mA	CV/CC
0-40	0-3	6265B	0.01% plus 200µV	0.02% plus 500µA	0.01% plus 200µV	0.02% plus 500µA	200µV	10mV	3mA	--	0.01% plus 200µV	0.01% plus 1mA	CV/CC
0-40	0-5	6291A	0.01% plus 1mV	0.05% plus 1mA	0.01% plus 1mV	0.06% plus 1mA	500µV	25mV	3mA	—	0.02% plus 500µV	0.02% plus 2.5mA	CV/CC
0-40	0-5	6266B	0.01% plus 200µV	0.02% plus 500µA	0.01% plus 200µV	0.02% plus 500µA	200µV	10mV	3mA	--	0.01% plus 200µV	0.01% plus 1mA	CV/CC
0-40	0-10	6267B	0.01% plus 200µV	0.02% plus 500µA	0.01% plus 200µV	0.02% plus 500µA	200µV	10mV	3mA	--	0.01% plus 200µV	0.01% plus 1mA	CV/CC
0-40	0-30	6268B	0.01% plus 200µV	0.02% plus 2mA	0.01% plus 200µV	0.02% plus 2mA	1mV	5mV	20mA	--	0.01% plus 200µV	0.01% plus 2mA	CV/CC
0-40	0-50	6269B	0.01% plus 200µV	0.02% plus 2mA	0.01% plus 200µV	0.02% plus 2mA	1mV	5mV	25mA	--	0.01% plus 200µV	0.01% plus 4mA	CV/CC
0-50	0.2	6217A	4mV	NA	4mV	NA	200µV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-50	0-0.2	6218A	4mV	500µA	4mV	600µA	200µV	1mV	150µA	500µA	0.02% plus 1mV	1mA	CV/CC
0-50 0-25	0-0.5 0-1	6220B	0.01% plus 2mV	0.01% plus 250µA	0.01% plus 2mV	0.01% plus 250µA	200µV	1mV	200µA	1mA	0.02% plus 1mV	0.02% plus 1mA	CV/CC
0-50 Dual	0-1	6228B	0.01% plus 1mV	0.01% plus 250µA	1mV	100µA	250µV	4mV	250µA	2mA	0.02% plus 200µV	0.02% plus 150µA	CV/CC
0-50	0-1.5	6226B	0.01% plus 2mV	0.01% plus 250µA	0.01% plus 2mV	0.01% plus 250µA	200µV	1mV	200µA	1mA	0.02% plus 500µV	0.02% plus 0.8mA	CV/CC
0-60 0-30	0.5 1	6206B	0.01% plus 4mV	NA	0.01% plus 4mV	NA	200µV	1mV	NA	NA	0.2% plus 1mV	NA	CV/CL
0-60	0-1	6294A	0.01% plus 2mV	0.01% plus 250µA	0.01% plus 2mV	0.01% plus 250µA	200µV	1mV	500µA	—	0.02% plus 500µV	0.02% plus 0.5mA	CV/CC

— indicates that information was not available at time of printing; NA indicates Not Applicable; DUAL indicates supply has two, independent, dc output voltages.

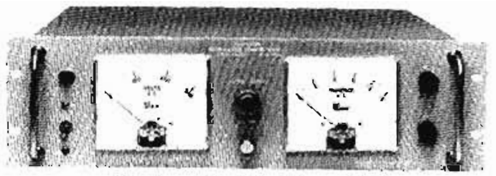
General purpose single output supplies



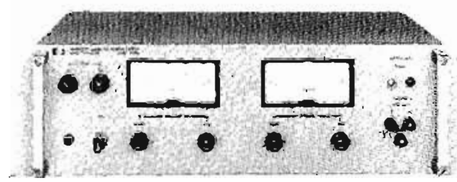
890A—320V/0.6A; p. 192



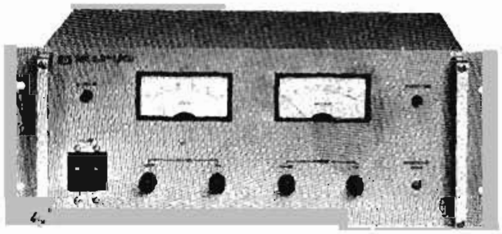
6263B—20V/10A; p. 188 6266B—40V/5A; p. 190
6265B—40V/3A; p. 190 6271B—60V/3A; p. 192



895A—320V/1.5A; p. 192



6256B—10V/20A; p. 186 6264B—20V/20A; p. 188
6267B—40V/10A; p. 190



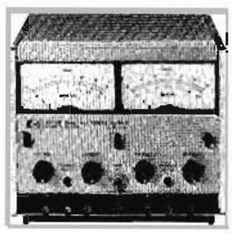
6259B—10V/50A; p. 188 6268B—40V/30A; p. 192
6260B—10V/10A; p. 188 6269B—40V/50A; p. 192
6261B—20V/50A; p. 190

6274B—60V/15A; p. 192

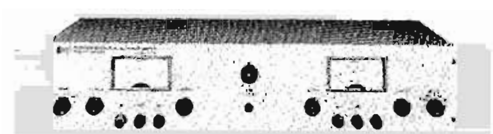
Stability		Transient Recovery		Series Par. Track.	Remote Prog.	Overvoltage Protection		Input Power	Dimensions (in./mm)			Options Available (page 201)	Price
Voltage	Current	Time	Level			Option	Price		W	H	D		
0.1% plus 2.5mV	0.1% plus 4mA	50µs	15mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 1.3A, 110W	8½ 216	3½ 89	14½ 368	7,8,9,11,13,14 28	$230
0.1% plus 2.5mV	0.1% plus 4mA	50µs	15mV	Yes	Yes	11	$110	115Vac ±10%, 48-440Hz, 2.6A, 235W	19 483	3½ 89	14½ 368	7,8,9,10,11,13,14 28	$470
0.1% plus 2.5mV	0.1% plus 7.5mA	50µs	15mV	Yes	Yes	11	$55	115Vac ±10%, 57-63Hz, 3.5A, 170W	8½ 216	5¼ 133	16 406	5,7,8,9,11,13,14 18	$350
0.03% plus 500µV	0.03% plus 3mA	50µs	10mV	Yes	Yes	Standard	NC	115Vac ±10%, 57-63Hz, 3A, 180W	19 483	3½ 89	17½ 445	5,7,8,9,10,13,14 20,21,22,27,28,40	$410
0.1% plus 2.5mV	0.1% plus 12.5mA	50µs	15mV	Yes	Yes	11	$55	115Vac ±10%, 57-63Hz, 5.5A, 280W	8½ 216	5¼ 133	16 406	5,7,8,9,11,13,14 18	$395
0.03% plus 500µV	0.03% plus 3mA	50µs	10mV	Yes	Yes	Standard	NC	115Vac ±10%, 57-63Hz, 4A, 325W	19 483	3½ 89	17½ 445	5,7,8,9,10,13,14 20,21,22,27,28,40	$460
0.03% plus 2mV	0.03% plus 3mA	50µs	10mV	Yes	Yes	Standard	NC	115Vac ±10%, 57-63Hz, 8A, 550W	19 483	5¼ 133	17½ 445	5,7,8,9,10,13,14 20,21,22,27,28,40	$550
0.03% plus 2mV	0.03% plus 5mA	50µs	10mV	Yes	Yes	Standard	NC	230Vac ±10%, 57-63Hz, 11A, 1600W	19 483	7 178	17½ 445	5,7,8,9,10,13,14 20,21,22,26,27,40	$745
0.03% plus 2mV	0.03% plus 10mA	50µs	10mV	Yes	Yes	Standard	NC	230Vac ±10%, 57-63Hz, 18A, 2500W	19 483	7 178	17½ 445	5,7,8,9,10,13,14 20,21,22,27,40	$895
0.1% plus 5mV	NA	50µs	15mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 0.25A, 25W	5¼ 133	3¼ 83	8 203	28	$98
0.1% plus 5mV	2.5mA	50µs	15mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 0.25A, 26W	5¼ 133	3¼ 83	8 203	28	$120
0.1% plus 5mV	0.1% plus 5mA	50µs	10mV	Yes	Yes	NA	NA	115Vac ±10%, 48-440Hz, 0.5A, 44W	5 1/8 130	6¼ 159	11 279	13,14,28,40	$295
0.2% plus 2mV	0.2% plus 1.5mA	50µs	10mV	Yes	Yes	Standard	NC	115 or 230Vac±10% 48-63Hz,2.7A,260W	7¾ 197	6 1/8 156	12 3/8 315	7,8,9,13,14	$525
0.1% plus 2.5mV	0.1% plus 4mA	50µs	10mV	Yes	Yes	NA	NA	115Vac ±10%, 48-63Hz, 1.8A, 164W	5 1/8 130	6¼ 159	11 279	13,14,28,40	$365
0.1% plus 5mV	NA	50µs	10mV	Yes	Yes	11	$51	115Vac ±10%, 48-440Hz, 1A, 66W	8½ 216	3½ 89	12½ 317	7,11,13,28	$190
0.1% plus 2.5mV	0.1% plus 2.5mA	50µs	15mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 1.3A, 114W	8½ 216	3½ 89	14½ 368	8,11,13,14,28	$245

— indicates that information was not available at time of printing; NA indicates Not Applicable; NC indicates No Charge

General purpose dual output supplies



6227B—25V/2A; p. 188
6228B—50V/1A; p. 190



6253A—20V/3A; p. 186 6255A—40V/1.5A; p. 190

Description

Models 6227B and 6228B. Each unit houses two identical, independently adjustable 50-watt power supplies. A convenient front panel switch selects one of two modes: independent or tracking. In the independent mode, the output voltage and current are controlled separately. In the tracking mode, the outputs are connected in series, and the controls for the left supply adjust the magnitude of both positive and negative outputs. The tracking mode is especially useful for powering operational amplifiers, push-pull stages, deflection systems, or any application where plus and minus voltages are required to track with an insignificant error. Overvoltage protection, Constant Voltage/Constant Current operation, remote programming, and remote sensing are among the standard features.

Models 6253A and 6255A. These 60-watt dual output supplies are packaged in a full-rack width case. Outputs are completely independent and are individually controlled and metered. Current limit protection, remote sensing, remote programming, and Auto-Series/Auto-Parallel/Auto-Tracking operation are standard. Single output versions of these supplies (Models 6284A and 6289A) are described on page 189.

Selection Guide (General Purpose Lab Supplies) continued

Rating Volts	Rating Amps	Model	Load Regulation Voltage	Load Regulation Current	Line Regulation Voltage	Line Regulation Current	Ripple & Noise Voltage rms	Ripple & Noise Voltage p-p	Ripple & Noise Current rms	Ripple & Noise Current p-p	Temperature Coefficient Voltage	Temperature Coefficient Current	Output Mode
0-60	0-3	6296A	0.01% plus 1mV	0.05% plus 1mA	0.01% plus 1mV	0.05% plus 1mA	500μV	25mV	3mA	--	0.02% plus 500μV	0.02% plus 1.5mA	CV/CC
0-60	0-3	6271B	0.01% plus 200μV	0.02% plus 500μA	0.01% plus 200μV	0.02% plus 500μA	200μV	10mV	3mA	--	0.01% plus 200μV	0.01% plus 1mA	CV/CC
0-60	0-15	6274B	0.01% plus 200μV	0.02% plus 500μA	0.01% plus 200μV	0.02% plus 500μA	200μV	20mV	5mA	--	0.01% plus 200μV	0.01% plus 2mA	CV/CC
0-100	0-0.1	6211A	8mV	NA	4mV	NA	200μV	1mV	NA	NA	0.02% plus 1mV	NA	CV/CL
0-100	0-0.1	6212A	8mV	500μA	4mV	500μA	200μV	1mV	150μA	500μA	0.02% plus 1mV	0.5mA	CV/CC
0-100	0-0.75	6299A	0.01% plus 2mV	0.01% plus 250μA	0.01% plus 2mV	0.01% plus 250μA	200μV	1mV	500μA	--	0.02% plus 500μV	0.02% plus 0.4mA	CV/CC
0-160	0-0.2	6207B	0.02% plus 2mV	200μA	0.02% plus 2mV	200μA	500μV	40mV	200μA	--	0.02% plus 1mV	0.02% plus 150μA	CV/CC
0-320	0-0.1	6209B	0.02% plus 2mV	200μA	0.02% plus 2mV	200μA	1mV	40mV	200μA	--	0.02% plus 1mV	0.02% plus 75μA	CV/CC
0-320	0.6	890A	0.007% or 10mV	NA	0.007% or 10mV	NA	1mV	--	NA	NA	0.03% plus 1.5mV	NA	CV/CL
0-320	1.5	895A	0.007% or 10mV	NA	0.007% or 10mV	NA	1mV	--	NA	NA	0.03% plus 1.5mV	NA	CV/CL
0-1000	0-200mA	6521A	0.005% or 20mV	2% or 1mA	0.005% or 20mV	1mA	1mV	--	2mA	--	0.012% plus 1mV	0.2% plus 0.2mA	CV/CC
0-1600	5mA	6515A	0.01% or 16mV	NA	0.01% or 16mV	NA	2mV	5mV	NA	NA	0.02% plus 2mV	NA	CV/CL
0-2000	0-100mA	6522A	0.005% or 20mV	2% or 1mA	0.005% or 20mV	1mA	1mV	--	1mA	--	0.012% plus 1mV	0.2% plus 0.1mA	CV/CC
0-3000	6mA	6516A	0.01% or 16mV	NA	0.01% or 16mV	NA	2mV	5mV	NA	NA	0.02% plus 2mV	NA	CV/CL
0-4000	0-50mA	6525A	0.005% or 20mV	2% or 1mA	0.005% or 20mV	1mA	1mV	--	500μA	--	0.012% plus 1mV	0.2% plus 0.05mA	CV/CC

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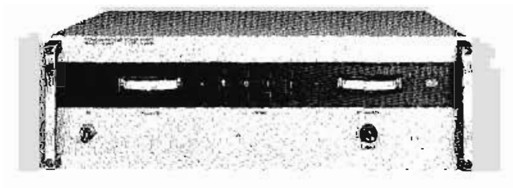
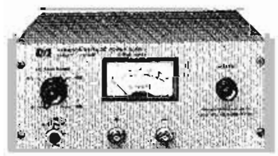
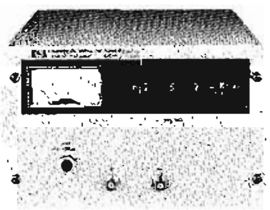
High voltage lab supplies



6521A—1000V/200mA; p. 192
6522A—2000V/100mA; p. 192
6525A—4000V/50mA; p. 192



6515A—1600V/5mA; p. 192



6516A—3000V/6mA; p. 192

Description

Models 6521A, 6522A, 6525A. These all-semiconductor high voltage supplies provide high voltage power in three ranges: 0-1 kV at 0-200 mA (6521A), 0-2 kV at 0-100 mA (6522A), and 0-4 kV at 0-50 mA (6525A). All models are well regulated and have sufficient output current to power devices such as TWT's, klystrons, magnetrons, backward-wave oscillators, high-power gas lasers, and electron beam welding devices. Constant Voltage/Constant Current operation with automatic crossover between modes is standard. Output voltage is set easily and precisely by a three-decade thumbwheel switch plus a thumbwheel vernier with 0.002% resolution.

Models 6515A and 6516A. These models are lower in cost, but have less power output and fewer features than the 6521A-series supplies. Their small size, low price, and short-circuit-proof operation make them ideal high-voltage laboratory supplies. The Model 6515A employs a multi-position range switch plus a vernier control which varies the output voltage from 0-100 V above the range switch setting. The Model 6516A uses a three-decade thumbwheel switch plus a thumbwheel vernier for precise output voltage control.

Stability Voltage	Stability Current	Transient Recovery Time	Transient Recovery Level	Series Par. Track.	Remote Prog.	Overvoltage Protection Option	Overvoltage Protection Price	Input Power	Dimensions (in./mm) W	H	D	Options Available (page 201)	Price
0.1% plus 2.5mV	0.1% plus 7.5mA	50µs	15mV	Yes	Yes	11	$55	115Vac ±10%, 57-63Hz, 4.5A, 250W	8½ 216	5¼ 133	16 406	5,7,8,9,11,13,14 19	$365
0.03% plus 500µV	0.03% plus 3mA	50µs	10mV	Yes	Yes	Standard	NC	115Vac ±10%, 57-63Hz, 4A, 300W	19 483	3½ 89	17½ 445	5,7,8,9,10,13,14 20,21,22,27,28,40	$460
0.03% plus 2mV	0.03% plus 5mA	50µs	10mV	Yes	Yes	Standard	NC	115Vac ±10%, 57-63Hz, 15A, 1200W	19 483	5¼ 133	17½ 445	5,7,8,9,10,13,14 20,21,22,27,28,40	$695
0.1% plus 5mV	NA	50µs	15mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 0.29A, 27W	5¼ 133	3¼ 83	8 203	28	$105
0.1% plus 5mV	1.3mA	50µs	15mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 0.29A, 28W	5¼ 133	3¼ 83	8 203	28	$130
0.1% plus 2.5mV	0.1% plus 2mA	50µs	15mV	Yes	Yes	11	$50	115Vac ±10%, 48-440Hz, 1.5A, 135W	8½ 216	3½ 89	14½ 368	8,11,13,14,28	$270
0.1% plus 5mV	0.1% plus 750µA	50µs	10mV	Yes	Yes	NA	NA	115Vac ±10%, 48-63Hz, 1A, 60W	8½ 216	3½ 89	12½ 317	8,13,14,28	$265
0.1% plus 5mV	0.1% plus 350µA	50µs	10mV	Yes	Yes	NA	NA	115Vac ±10%, 48-63Hz, 1A, 60W	8½ 216	3½ 89	12½ 317	8,13,14,28	$255
0.1% plus 5mV	NA	100µs	20mV	No	Yes	NA	NA	115Vac ±10%, 57-63Hz, 3.9A, 256W	19 483	3½ 89	16¾ 426	NA	$530
0.1% plus 5mV	NA	100µs	20mV	No	Yes	NA	NA	115Vac ±10%, 57-63Hz, 8.7A, 585W	19 483	5¼ 133	16¾ 426	NA	$675
0.036% plus 3mV	0.25% plus 0.5mA	50µs	0.005% or 20mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 4A, 270W	19 483	5¼ 133	18 457	NA	$855
0.05% plus 5mV	NA	100µs	0.01% or 16mV	No	No	NA	NA	115Vac ±10%, 60 ±0.3Hz, 162mA, 19W	8½ 216	3½ 89	11¾ 299	13	$250
0.036% plus 3mV	0.25% plus 0.25mA	50µs	0.005% or 20mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 4A, 270W	19 483	5¼ 133	18 457	NA	$855
0.05% plus 5mV	NA	100µs	0.01% or 16mV	No	No	NA	NA	115Vac ±10%, 57-63Hz, 1A, 40W	8½ 216	5¼ 133	16 406	5,18	$340
0.036% plus 3mV	0.25% plus 0.12mA	50µs	0.005% or 20mV	No	No	NA	NA	115Vac ±10%, 48-440Hz, 4A, 270W	19 483	5¼ 133	18 457	NA	$855

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POWER SUPPLIES

HIGH POWER INDUSTRIAL SUPPLIES
300-11,000 Watts
Models 6427B-6483C

Description

Nineteen models covering a range from 0-8 V to 0-600 V with power ratings up to 11 kilowatts make up this series of heavy duty industrial-type power supplies. All models employ silicon controlled rectifier regulation techniques and feature Constant Voltage/Constant Current operation, remote sensing, remote resistance and voltage programming, and Auto-Series/Auto-Parallel operation. Overvoltage protection is available as an option. The nineteen models are divided into three categories according to the highest power rating within the group. The groups are 1 kilowatt, 3 kilowatts, and 11 kilowatts.

1 Kilowatt Supplies. Eight models covering ratings from 0-20 V at 0-15 A to 1-600 V at 5 mA-1.5 A make up this group. Four of the models are rated at approximately 300 watts output and are packaged in 3½" high rack-mounting cabinets. The remaining four models are rated at approximately 1000 watts and are packaged in 5½" high cabinets. Convection cooling is employed on the 300 watt units, while cooling fans are used on the higher power models.

3 Kilowatt Supplies. Models 6453A, 6456B, and 6459A make up this group of medium power SCR regulated supplies. Output ratings are 0-15 V at 0-200 A (6453A), 0-36 V at 0-100 A (6456B) and 0-64 V at 0-50 A (6459A). Combined constant voltage load and line regulation for the three models is 0.25% plus 10 mV. These supplies have excellent line transient immunity (insensitive to disturbances lasting 5 to 10 cycles) and fast load transient recovery. In addition to overload protection, the supplies also have an ac line dropout protection circuit which turns off the rectifiers and opens the output bus in the event of ac power failure. The units measure 19" W x 14" H x 18¼" D and are designed for rack mounting. Rack mounting accessories are described on page 201.

10 Kilowatt Supplies. This category includes nine models with ratings from 0-8 V at 0-1000 A to 0-600 V at 0-15 A. Units are housed in a 16¾" W x 26½" H x 26⅛" D cabinet, weighing approximately 500 pounds. Rack mounting hardware and casters are available at additional cost (see page 201). Serviceability of these units is enhanced by a modular design and the use of plug-in amplifier boards. An over-temperature cut-out circuit provides added protection

Selection Guide (High Power Industrial Supplies)

Rating Volts	Rating Amps	Model	Load Regulation Voltage	Load Regulation Current	Line Regulation Voltage	Line Regulation Current	Ripple & Noise rms/p-p	Temperature Coefficient Voltage	Temperature Coefficient Current
0-8	0-1000	6464C	0.5% plus 5mV	0.1% plus 1A	0.05% plus 5mV	0.1% plus 1A	80mV/1V	0.03% plus 100μV	0.06% plus 0.25A
0-15	0-200	6453A	0.2% plus 10mV comb. line & load	1% or 2A comb. line & load	0.2% plus 10mV comb. line & load	1% or 2A comb. line & load	150mV	0.05% plus 2mV	1.2A
0-16 0-18	0-600 0-600	6466C	0.05% plus 5mV	0.1% plus 0.6A	0.05% plus 5mV	0.1% plus 0.6A	180mV/1V	0.03% plus 200μV	0.06% plus 0.15A
0-20	0-15	6427B	20mV	150mA	10mV	160mA	40mV/400mV	0.03% plus 3mV	45mA
0-20	0-45	6428B	40mV	450mA	20mV	450mA	40mV/500mV	0.03% plus 3mV	135mA
0-36	0-10	6433B	36mV	100mA	18mV	100mA	36mV/400mV	0.03% plus 5mV	30mA
0-36	0-100	6456B	0.2% plus 10mV comb. line & load	1% or 1A comb. line & load	0.2% plus 10mV comb. line & load	1% or 1A comb. line & load	180mV	0.05% plus 2mV	0.6A
0-36	0-300	6469C	0.05% plus 5mV	0.1% plus 0.3A	0.05% plus 5mV	0.1% plus 0.3A	180mV/1V	0.03% plus 400μV	0.06% plus 0.1A
0-40	0-25	6434B	40mV	200mA	18mV	200mA	40mV/500mV	0.03% plus 5mV	75mA
0-60	0-5	6438B	60mV	50mA	30mV	50mA	120mV/400mV	0.03% plus 10mV	15mA
0-60	0-15	6439B	120mV	150mA	60mV	150mA	60mV/500mV	0.03% plus 10mV	45mA
0-64	0-50	6459A	0.2% plus 10mV comb. line & load	1% or 0.5A comb. line & load	0.2% plus 10mV comb. line & load	1% or 0.5A comb. line & load	160mV	0.05% plus 2mV	0.3A
0-64	0-150	6472C	0.05% plus 100mV	0.1% plus 0.15A	0.05% plus 100mV	0.1% plus 0.15A	160mV/1V	0.03% plus 4mV	0.06% plus 85mA
0-110	0-100	6475C	0.05% plus 100mV	0.1% plus 0.1A	0.05% plus 100mV	0.1% plus 0.1A	220mV/2V	0.03% plus 5mV	0.06% plus 75mA
0-120	0-2.5	6443B	120mV	25mA	60mV	25mA	240mV/400mV	0.03% plus 20mV	8mA
0-220	0-60	6477C	0.05% plus 100mV	0.1% plus 50mA	0.05% plus 100mV	0.1% plus 50mA	330mV/2V	0.03% plus 8mV	0.06% plus 65mA
0-300	0-35	6479C	0.05% plus 100mV	0.1% plus 35mA	0.05% plus 100mV	0.1% plus 35mA	330mV/3V	0.03% plus 11mV	0.06% plus 60mA
0-440, 500,600	0-25 20,15	6483C	0.05% plus 100mV	0.1% plus 35mA	0.05% plus 100mV	0.1% plus 35mA	600mV/5V	0.03% plus 20mV	0.06% plus 60mA
1-600	5mA-1.5A	6448B	1% plus 400mV	2% plus 10mA	600mV	15mA	600mV/2V	0.03% plus 100mV	5mA

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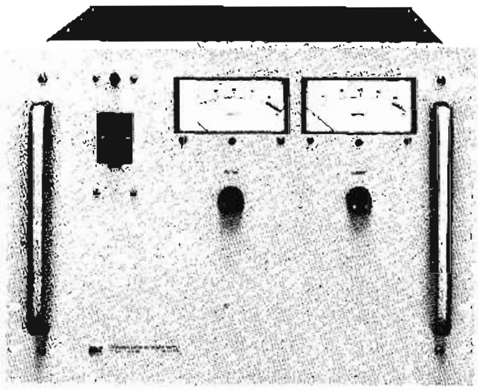
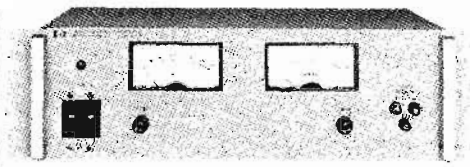
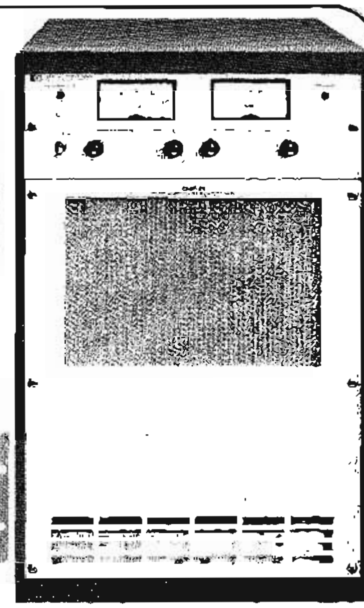


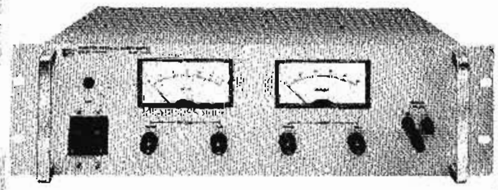
6453A, 6456B, 6459A



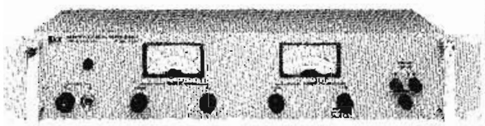
6448B



6464C-6483C



6428B, 6434B, 6439B



6427B, 6433B, 6438B, 6443B

Stability Voltage	Stability Current	Transient Recovery Time	Transient Recovery Level	Floating, up to	Overvoltage Protection Option	Overvoltage Protection Price	Input Power	Dimensions (in./mm) W	H	D	Options Available (page 201)	Price
0.3% plus 1mV	0.6% plus 1A	50ms 100ms	1.5V 500mV	100V	NA	NA	Option 1,2,3,31,32 50A per phase @ 230V	16¾ 426	26¼ 667	26 1/8 664	1,2,3,5,23,31,32	$3500
0.25% plus 10mV	6A	50ms	150mV	300V	6	$350	Option 1,2,3,31,32 14A per phase @ 230V	19 483	14 356	18¼ 464	1,2,3,5,6,10,31,32	$1425
0.2% plus 1mV	0.5% plus 0.6A	50ms 100ms	1.5V 500mV	100V	6	$500	Option 1,2,3,31,32 50A per phase @ 230V	16¾ 426	26¼ 667	26 1/8 664	1,2,3,5,6,23,31,32	$2800
0.1% plus 10mV	150mA	200ms	200mV	300V	NA	NA	115Vac±10%, 57-63Hz, 6.5A, 450W	19 483	3½ 89	17½ 445	5,10,27,28	$425
0.1% plus 10mV	450mA	200ms	200mV	300V	NA	NA	115Vac±10%, 57-63Hz, 17A, 1200W	19 483	5¼ 133	16¾ 426	5,10,27,28	$585
0.1% plus 15mV	100mA	200ms	200mV	300V	NA	NA	115Vac±10%, 57-63Hz, 7A, 450W	19 483	3½ 89	17½ 445	5,10,27,28	$395
0.25% plus 10mV	3A	50ms	300mV	300V	6	$300	Option 1,2,3,31,32 14A per phase @ 230V	19 483	14 356	18¼ 464	1,2,3,5,6,10,31,32	$1325
0.15% plus 1mV	0.4% plus 0.4A	50ms 100ms	1.5V 500mV	100V	6	$450	Option 1,2,3,31,32 50A per phase @ 230V	16¾ 426	26¼ 667	26 1/8 664	1,2,3,5,6,23,31,32	$2500
0.1% plus 20mV	250mA	200ms	200mV	300V	NA	NA	115Vac±10%, 57-63Hz, 19A, 1300W	19 483	5¼ 133	16¾ 426	5,10,27,28	$570
0.1% plus 30mV	50mA	200ms	300mV	300V	NA	NA	115Vac±10%, 57-63Hz, 6.5A, 400W	19 483	3½ 89	17½ 445	5,10,27,28	$395
0.1% plus 30mV	150mA	200ms	600mV	300V	NA	NA	115Vac±10%, 57-63Hz, 17A, 1200W	19 483	5¼ 133	16¾ 426	5,10,27,28	$560
0.25% plus 10mV	1.5A	50ms	600mV	300V	6	$300	Option 1,2,3,31,32 14A per phase @ 230V	19 483	14 356	18¼ 464	1,2,3,5,6,10,31,32	$1325
0.15% plus 16mV	0.3% plus 0.35A	50ms 100ms	2V 750mV	100V	6	$400	Option 1,2,3,31,32 50A per phase @ 230V	16¾ 426	26¼ 667	26 1/8 664	1,2,3,5,6,23,31,32	$2800
0.15% plus 20mV	0.3% plus 300mA	50ms 100ms	2.5V 1V	300V	6	$400	Option 1,2,3,31,32 50A per phase @ 230V	16¾ 426	26¼ 667	26 1/8 664	1,2,3,5,6,23,31,32	$2800
0.1% plus 60mV	25mA	200ms	600mV	300V	NA	NA	115Vac±10%, 57-63Hz, 6.5A, 400W	19 483	3½ 89	17½ 445	5,10,27,28	$385
0.15% plus 35mV	0.3% plus 250mA	50ms 100ms	5V 2V	300V	6	$300	Option 1,2,3,31,32 50A per phase @ 230V	16¾ 426	26¼ 667	26 1/8 664	1,2,3,5,6,23,31,32	$2800
0.15% plus 45mV	0.3% plus 250mA	50ms 100ms	7V 3V	300V	6	$300	Option 1,2,3,31,32 50A per phase @ 230V	16¾ 426	26¼ 667	26 1/8 664	1,2,3,5,6,23,31,32	$2800
0.15% plus 80mV	0.3% plus 250mA	50ms 100ms	12V 5V	100V	6	$300	Option 1,2,3,31,32 50A per phase @ 230V	16¾ 426	26¼ 667	26 1/8 664	1,2,3,5,6,23,31,32	$2800
0.1% plus 300mV	15mA	200ms	3V	300V	NA	NA	115Vac±10%, 57-63Hz, 16A, 1200W	19 483	5¼ 133	16¾ 426	5,10,27,28	$595

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PRECISION POWER SUPPLIES

High stability, low-cost calibrator

Models 6101A-6116A

Description

Hewlett-Packard precision power supplies are high-accuracy instruments designed for use as low-cost calibrators, working voltage standards, systems reference supplies, or high-performance lab supplies. They are ideal for applications requiring an accurate, highly stable, and easy-to-use source of dc voltage. Operating characteristics of these supplies are one or two orders of magnitude better than typical laboratory supplies.

Models 6114A/6115A. These models feature a four-digit pushbutton switch for fast and accurate setting of output voltage to within 0.025% plus 1 mV. Additional features include 5-minute warmup, automatic dual-range operation, built-in overvoltage protection, overvoltage and current mode indicators, front panel metering, and Auto-Series/Auto-Parallel/Auto-Tracking capability. Models 6104A/6105A have similar features, but employ a ten-turn potentiometer for output voltage control.

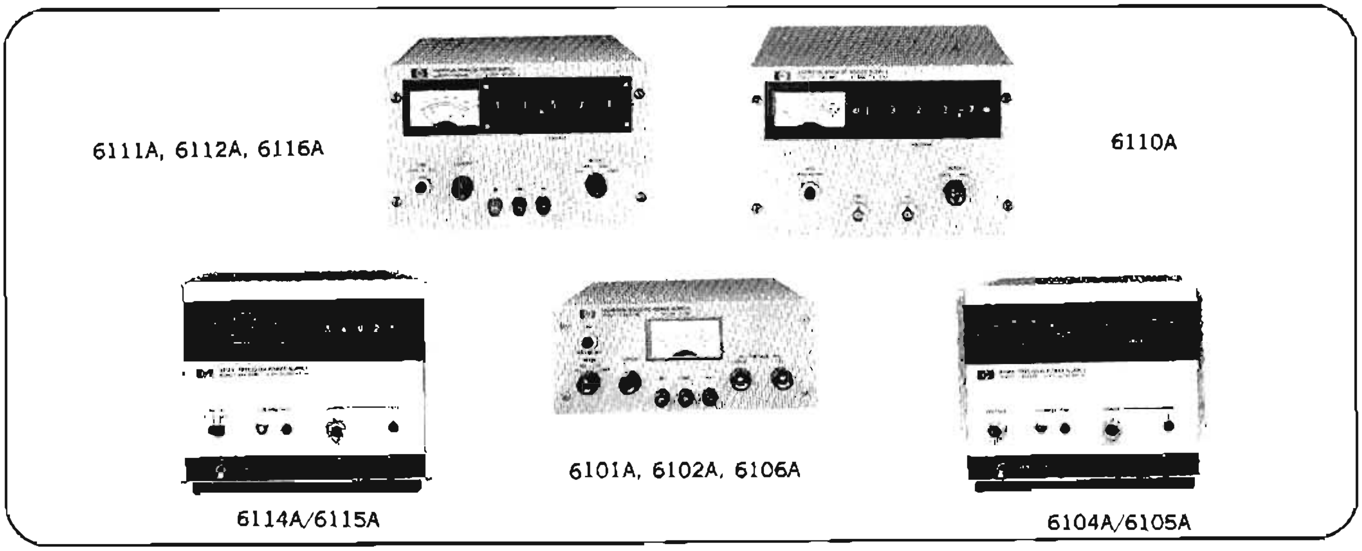
Models 6111A, 6112A, and 6116A. These models have fewer features and somewhat lower performance than the 6114A/6115A units, but are also lower in cost. Standard features include a precise five-digit thumb-wheel voltage control, adjustable current limit protection, dual-function metering, and Auto-Series/Auto-Tracking operation. Models 6101A, 6102A, and 6106A are similar to models 6111A, 6112A, and 6116A, but employ coarse and fine potentiometers to adjust output voltage.

Model 6110A. The 6110A is a precision high-voltage power supply capable of supplying 0-3000 V at 0-6 mA. It can be used in any application requiring a precise and stable source of high-voltage dc power. Standard features include fixed current limit protection, dual-function metering and a precise five-digit thumb-wheel voltage control.

Selection Guide (Precision Power Supplies)

Rating Volts	Rating Amps	Model	Load Regulation Voltage	Load Regulation Current	Line Regulation Voltage	Line Regulation Current	Ripple & Noise Voltage (rms/p-p)	Ripple & Noise Current (rms/p-p)	Temperature Coefficient Voltage	Temperature Coefficient Current	Output Voltage Accuracy	Output Mode
0-10	0-2	6113A	0.001% plus 100μV	NA	0.001%	NA	40μV/100μV	NA	0.001% plus 10μV	NA	0.1% plus 1mV	CV/CL
0-20	0-1	6101A	0.001% plus 100μV	NA	0.001%	NA	40μV/100μV	NA	0.005% plus 30μV	NA	NA	CV/CL
0-20	0-1	6111A	0.001% plus 100μV	NA	0.001%	NA	40μV/100μV	NA	0.001% plus 10μV	NA	0.1% plus 1mV	CV/CL
0-20 20-40	0-2 0-1	6104A	0.0005% plus 100μV	0.01% plus 500μA	0.0005% plus 40μV	0.005% plus 40μA	40μV/100μV	200μA/1mA	0.005% plus 25μV	0.02% plus 50μA	NA	CV/CC
0-20 20-40	0-2 0-1	6114A	0.0005% plus 100μV	plus 500μA	0.0005% plus 40μV	0.005% plus 40μA	40μV/100μV	200μA/1mA	0.001% plus 15μV	0.02% plus 50μA	0.025% plus 1.0mV	CV/CC
0-40	0-0.5	6102A	0.001% plus 100μV	NA	0.001%	NA	40μV/100μV	NA	0.005% plus 50μV	NA	NA	CV/CL
0-40	0-0.5	6112A	0.001% plus 100μV	NA	0.001%	NA	40μV/100μV	NA	0.001% plus 10μV	NA	0.1% plus 1mV	CV/CL
20-40 0-20	0-1 0-2	6104A	0.0005% plus 100μV	0.01% plus 500μA	0.0005% plus 40μV	0.005% plus 40μA	40μV/100μV	200μA/1mA	0.005% plus 25μV	0.02% plus 50μA	NA	CV/CC
20-40 0-20	0-2 0-1	6114A	0.0005% plus 100μV	plus 500μA	0.0005% plus 40μV	0.005% plus 40μA	40μV/100μV	200μA/1mA	0.001% plus 15μV	0.02% plus 50μA	0.025% plus 1.0mV	CV/CC
0-50 50-100	0-0.8 0-0.4	6105A	0.0005% plus 50μV	0.01% plus 500μA	0.0005% plus 100μV	0.005% plus 20μA	40μV/100μV	200μA/1mA	0.005% plus 50μV	0.02% plus 25μA	NA	CV/CC
0-50 50-100	0-0.8 0-0.4	6115A	0.0005% plus 50μV	0.01% plus 500μA	0.0005% plus 100μV	0.005% plus 20μA	40μV/100μV	200μA/1mA	0.001% plus 15μV	0.02% plus 25μA	0.025% plus 1.0mV	CV/CC
0-100	0-200mA	6106A	0.001% plus 100μV	NA	0.001%	NA	40μV/100μV	NA	0.005% plus 100μV	NA	NA	CV/CL
0-100	0-200mA	6116A	0.001% plus 100μV	NA	0.001%	NA	40μV/100μV	NA	0.001% plus 10μV	NA	0.1% plus 1mV	CV/CL
50-100 0-50	0-0.4 0-0.8	6105A	0.0005% plus 50μV	0.01% plus 500μA	0.0005% plus 100μV	0.005% plus 20μA	40μV/100μV	200μA/1mA	0.005% plus 50μV	0.02% plus 25μA	NA	CV/CC
50-100 0-50	0-0.4 0-0.8	6115A	0.0005% plus 50μV	plus 500μA	0.0005% plus 100μV	plus 20μA	40μV/100μV	200μA/1mA	0.001% plus 15μV	0.02% plus 25μA	0.025% plus 1.0mV	CV/CC
0-3000	6mA	6110A	0.001% plus 100μV	NA	0.001%	NA	2mV/5mV	NA	0.001% plus 50μV	NA	0.1% plus 100mV	CV/CL

— indicates that information was not available at time of printing; NA indicates Not Applicable;



6111A, 6112A, 6116A

6110A

6114A/6115A

6101A, 6102A, 6106A

6104A/6105A

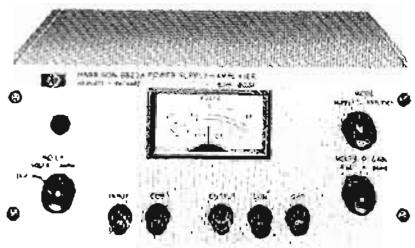
Stability Voltage 8-hour	Stability Voltage 90-day	Stability Current 8-hour	Resolution Voltage	Resolution Cur.	Overvoltage Protection Option	Overvoltage Protection Price	Input Power	Dimensions (in./mm) W	H	D	Options Available (page 201)	Price
0.01% plus 100µV	—	NA	20µV	NA	11	$50	115Vac ±10%, 48-63Hz, 0.5A, 52W	8½ 216	5¼ 133	12½ 318	11,28,40	$375
0.01% plus 300µV	—	NA	0.002% plus 100µV	NA	11	$50	115Vac ±10%, 48-63Hz, 0.5A, 52W	8½ 216	3½ 89	12½ 318	11,28,40	$266
0.01% plus 100µV	—	NA	200µV	NA	11	$50	115Vac ±10%, 48-63Hz, 0.5A, 52W	8½ 216	5¼ 133	12½ 318	11,28,40	$375
0.005% plus 50µV	0.01% plus 100µV	0.25% plus 7mA	8mV	15mA	Standard	NC	104-127 or 208-254VAC (switchable), 48-440Hz, 150 VA max.	7¾ 197	6½ 166	13¼ 336	8,13,14	$440
0.0015% plus 15µV	0.0075% plus 30µV	0.25% plus 7mA	200µV	15mA	Standard	NC	104-127 or 208-254VAC (switchable), 48-440Hz, 150 VA max.	7¾ 197	6½ 166	13¼ 336	8,14	$525
0.01% plus 500µV	--	NA	0.002% plus 100µV	NA	11	$50	115Vac ±10%, 48-63Hz, 0.5A, 52W	8½ 216	3½ 89	12½ 318	11,28,40	$266
0.01% plus 100µV	—	NA	200µV	NA	11	$50	115Vac ±10%, 48-63Hz, 0.5A, 52W	8½ 216	5¼ 133	12½ 318	11,28,40	$375
0.005% plus 50µV	0.01% plus 100µV	0.25% plus 7mA	8mV	15mA	Standard	NC	104-127 or 208-254VAC (switchable), 48-440Hz, 150 VA max.	7¾ 197	6½ 166	13¼ 336	8,13,14	$440
0.0015% plus 15µV	0.0075% plus 30µV	0.25% plus 7mA	200µV	15mA	Standard	NC	104-127 or 208-254VAC (switchable), 48-440Hz, 150 VA max.	7¾ 197	6½ 166	13¼ 336	8,14	$525
0.005% plus 50µV	0.01% plus 100µV	0.25% plus 4mA	16mV	8mA	Standard	NC	104-127 or 208-254VAC (switchable), 48-440Hz, 150 VA max.	7¾ 197	6½ 166	13¼ 336	8,13,14	$455
0.0015% plus 15µV	0.0075% plus 30µV	0.25% plus 4mA	200µV	8mA	Standard	NC	104-127 or 208-254VAC (switchable), 48-440Hz, 150 VA max.	7¾ 197	6½ 166	13¼ 336	8,14	$540
0.01% plus 1mV	NA	NA	0.002% plus 100µV	NA	11	$50	115Vac ±10%, 48-63Hz, 0.5A, 52W	8½ 216	3½ 89	12½ 318	11,28	$265
0.01% plus 100µV	NA	NA	200µV	NA	11	$50	115Vac ±10%, 48-63Hz, 0.5A, 52W	8½ 216	5¼ 133	12½ 318	11,28	$375
0.005% plus 50µV	0.01% plus 100µV	0.25% plus 4mA	16mV	8mA	Standard	NC	104-127 or 208-254VAC (switchable), 48-440Hz, 150 VA max.	7¾ 197	6½ 166	13¼ 336	8,13,14	$455
0.0015% plus 15µV	0.0075% plus 30µV	0.25% plus 4mA	200µV	8mA	Standard	NC	104-127 or 208-254VAC (switchable), 48-440Hz, 150 VA max.	7¾ 197	6½ 166	13¼ 336	8,14	$540
0.01% plus 500µV	NA	NA	20mV	NA	NA	NA	115Vac ±10%, 57-63Hz, 1A, 50W	8½ 216	5¼ 133	16 406	5,18	$520

-- indicates that information was not available at time of printing; NA indicates Not Applicable; NC indicates No Charge

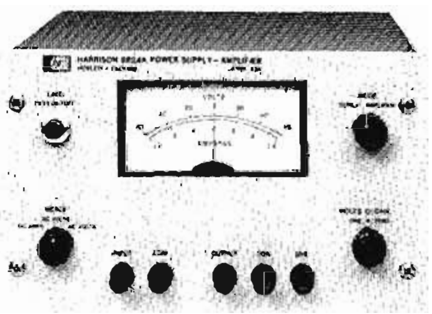
DC POWER SUPPLY/AMPLIFIER

Bipolar output; frequency response to 20 kHz

Models 6823A, 6824A, 712C



6823A



6824A

Models 6823A and 6824A are general-purpose laboratory instruments capable of a variety of operating modes. Two or more of these units can be connected in Auto-Series to obtain greater voltage capability. High speed constant current operation can be obtained by simply adding an external resistor in series with the load and making minor changes in the rear barrier strapping.

When used as a DC Power Supply, either model can be controlled from the front panel, or remotely programmed with resistance or voltage. As a power amplifier, each unit offers a signal-to-noise ratio of 80 dB at full output with low distortion, and 20 dB gain from dc to 20 kHz.

Specifications

Power Supply			
Model		**6823A**	**6824A**
Output:	DC Voltage	−20 to + 20 Vdc	−50 to + 50 Vdc
	DC Current	0–0.5A	0–1.0A
Load Regulation:		0.02% plus 5 mV	
Line Regulation:		0.02% plus 5 mV	
Ripple & Noise:		2 mV rms	10 mV rms
Load Transient Recovery Time:		Less than 100 μsec to within 5 mV +0.02% of the nominal output.	
Output:	DC Voltage	40 V P-P	100 V P-P
	DC Current	0–0.5 A	0-1.0A
Voltage Gain:		Variable 0–10 (20 dB) output inverted	
Frequency Response:		At full output = 3 dB from dc to 20 kHz.	
Max. Phase Shift:		dc - 180°, 100 Hz - 181°, 1 kHz - 183°, 10 kHz - 205°, 20 kHz - 225°	
Distortion:		<0.02% @ 1 kHz and full output	
Input Impedance:		2 k ohms approx.	
Common Specifications			
AC Input:		115 Vac ± 10%, 1 phase, 48–440 Hz; 0.3 A, 24 W @ 115 Vac	115 Vac ± 10%, 1 phase, 48–63 Hz; 1.3 A, 96 W @ 115 Vac
Price:		$240	$395
Options Available: (see page 201)		028 ($10)	007 ($35), 028 ($10)
Accessories Available		(see page 201)	

MODEL 712C MULTIPLE-OUTPUT SUPPLY

Specifications

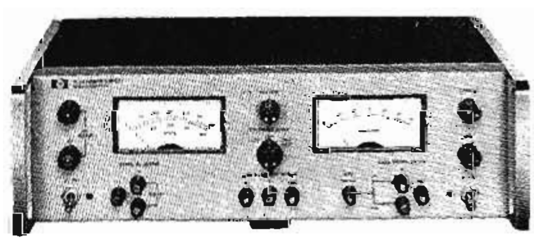
Output

DC main (CV/CC): 0 to 500 V at 0 to 200 mA.
DC fixed bias: −300 V at 0 to 50 mA.
DC variable bias: 0 to −150 V at 5 mA.
AC unregulated: 6.3 V CT at 10 A.

Input: 115 Vac ±10%, 57-63 Hz, 2 A at 115 Vac (230 Vac input not available).

CV Load Regulation: The constant voltage load regulation is given for a load current change equal to the current rating of the supply.
DC main: 0.01% +5 mV.
DC fixed bias: 50 mV.
DC variable bias is tied to fixed bias, hence source regulation is same for fixed bias. Internal impedance is 0 to 10,000 ohms, depending on bias control setting.

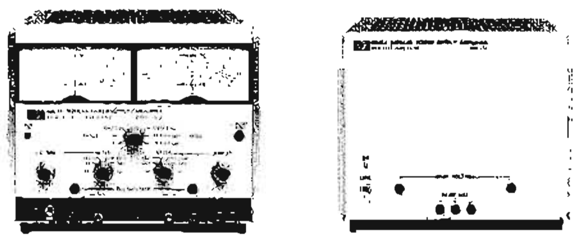
CC Load Regulation: The constant current load regulation is given for a load voltage change equal to the voltage rating of the supply.
DC main. 0.25 mA.



712C

Price: $545.
Option 005: 50 Hz input, add $25.

DC POWER SUPPLY/AMPLIFIER
BiPolar output, frequency response to 40 kHz
Models 6825A-6227A, 6830A-6832A



6825A-6827A **NEW** 6830A-6832A

Description

This new series of power amplifiers offers higher performance and more versatility than Power Supply/Amplifier Models 6823A and 6824A. New features include dual range output, CV/CC operation, bipolar overvoltage protection, and metering of ac and dc voltage and current. Output voltage and current as a dc supply, or gain as a power amplifier, are remotely programmable and are compatible with Hewlett-Packard Multiprogrammer Systems.

Each standard model is available in a blank panel version for remote programming applications where metering and front panel access to function switching is not required.

MODELS	Standard (Blank Panel)	6825A (6830A)	6826A (6831A)	6827A (6832A)
OPERATION AS A POWER SUPPLY				
OUTPUT	DC Voltage High Range	−20 to +20V	−50 to +50V	−100 to +100V
	DC Current	0–1.0A	0–1.0A	0–0.5A
LOAD REGULATION	Voltage High Range	0.5mV + .01%	1mV + .01%	1mV + .01%
	Low Range	0.1mV + .01%	0.2mV + .01%	0.2mV + .01%
	Current	0.01% + 250μA	0.01% + 250μA	0.01% + 250μA
LINE REGULATION	Voltage High Range	2mV + .01%	5mV + .01%	10mV + .01%
	Low Range	0.2mV + .01%	0.5mV + .01%	1mV + .01%
	Current	0.01% + 250μA	0.01% + 250μA	0.01% + 250μA
RIPPLE & NOISE (20Hz-20mHz) (rms/p-p)	Voltage High Range	2.5mV/8mV	6mV/25mV	10mV/30mV
	Low Range	2mV/8mV	2.5mV/8mV	2.5mV/8mV
	Current	0.8mA/2mA	0.8mA/2mA	0.4mA/1mA
LOAD TRANSIENT RECOVERY TIME	Voltage	20mV	50mV	100mV
	Time	150μs	150μs	150μs
OUTPUT METERING — Standard Models Only				
VOLTAGE	DC	−24 to +24V	−60 to +60V	−120 to +120V
	AC	0-16Vrms	0-40Vrms	0-80Vrms
CURRENT	DC	−1.2 to +1.2A	−1.2 to +1.2A	−0.6 to +0.6A
	AC	0-0.8A	0-0.8A	0-0.4A
	DC	24V, 6V	60V, 6V	120V, 12V
	AC	16V, 4V	40V, 4V	80V, 8V

MODELS	Standard (Blank Panel)	6825A (6830A)	6826A (6831A)	6827A (6832A)
OPERATION AS A POWER AMPLIFIER				
OUTPUT	DC Voltage High Range	20V pk	50V pk	100V pk
	Low Range	5V pk	5V pk	10V pk
	DC Current	1.0A pk	1.0A pk	0.5A pk
VOLTAGE GAIN	Fixed (Inverting)	4x 1x	10x 1x	20x 2x
	Variable (Non-invert.)	0-8 0-2	0-20 0-2	0-40 0-4
FREQUENCY RESPONSE (+1, -3db)	Fixed Gain	dc-40kHz	dc-40kHz	dc-30kHz
	Variable Gain	dc-15kHz	dc-15kHz	dc-15kHz
DISTORTION	1kHz & full output	0.1% THD	0.1% THD	0.1% THD
FIXED GAIN ACCURACY (at DC)		4x:±0.1% ±2mV	10x:±0.1% ±5mV	20x:±0.1% ±10mV
		1x:±0.1% ±0.5mV	1x:±0.1% ±0.5mV	2x:±0.1% ±1mV
REMOTE PROGRAMMING CHARACTERISTICS				
RESISTANCE PROGRAMMING COEFFICIENT	Voltage High Range	500Ω/V	200Ω/V	100Ω/V
	Low Range	2000Ω/V	2000Ω/V	1000Ω/V
	Current	10Ω/mA	10Ω/mA	10Ω/mA
Gain, Variable* $A_V = \frac{k R_f}{10.24k\Omega}$	High Range	$4R_f/10.24K\Omega$	$10R_f/10.24K\Omega$	$20R_f/10.24K\Omega$
	Low Range	$R_f/10.24K\Omega$	$R_f/10.24K\Omega$	$2R_f/10.24K\Omega$
VOLTAGE PROGRAMMING COEFFICIENT	Voltage	See Voltage Gain Specification		
	Current	1A/V	1A/V	1A/V
PROGRAMMING SPEED Between 10% and 90% of value at fixed gain.		50μs	50μs	50μs

*Where k is the constant indicated, and R_f is the programming resistance.

Additional Specifications

Power: 104-127/208-254 Vac. Switchable. 48-440 Hz.

Temperature: Operating: 0 to 55°C; Storage: −40 to 75°C.

Cooling: Convection.

Output Mode: CV/CC, Auto-series, Auto-parellel, Auto-tracking.

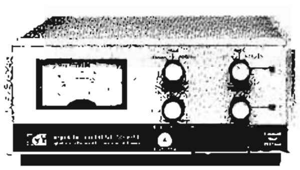
Isolation: 300 V (dc or peak) maximum can be placed between either output terminal and ground.

POWER SUPPLIES

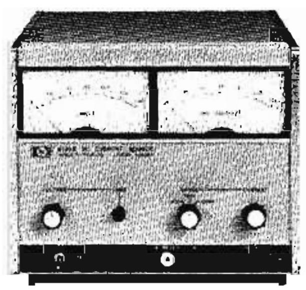
CONSTANT CURRENT SOURCES

Precise regulation and resolution

Models 6177B, 6181B, 6186B



6177B, 6181B



6186B

Description

These solid-state constant-current sources have excellent ripple, regulation, drift, and output impedance characteristics, making them ideal for semiconductor circuit development, component testing, and precision electroplating applications.

In addition, the high-speed remote programming characteristics lend these supplies to diverse applications, such as testing and sorting of semiconductors, resistors, relays, meters, etc. The capability of superimposing ac modulation on the dc output permits the supplies to be used for measurement of dynamic or incremental impedance of circuit components.

Specifications

Load regulation: less than 25 ppm of output +5 ppm of range switch setting for a load change which causes the output voltage to vary from zero to maximum.

Line regulation: less than 25 ppm of output +5 ppm of range switch setting for a 10% change in the line voltage.

Load transient recovery time: less than 200 μs for output current recovery to within 1% of the nominal output current following a full load change in output voltage.

Temperature coefficient: output change per degree C is less than 75 ppm of output current +5 ppm of range switch setting.

Stability: less than 100 ppm of output current +25 ppm of range switch setting after 1 hour warmup.

Resolution: 0.02% of range switch setting.

Temperature: operating, 0 to 55°C; storage, −40 to +75°C.

Dimensions:
6177B, 6181B: 7¾" wide, 3-7/16" high, 12⅜" deep.
6186B: 7¾" wide, 6-7/32" high, 12⅜" deep.

Weight:
6177B, 6181B: 10 lbs net, 13 lbs shipping
6186B: 13 lbs net, 17 lbs shipping.

Options
014: three digit graduated decadial current control, add $35
028: 230 V ac, (Models 6177B and 6181B only), add $10.

Model			6177B	6181B	6186B
Output Current			0–500 mA	0–250 ma	0–100 mA
Voltage Compliance			0–50 Vdc	0–100 Vdc	0–300 Vdc
Output Ranges		A	0–5 mA	0–2.5 mA	0–1 mA
		B	0–50 mA	0–25 mA	0–10 mA
		C	0–500 mA	0–250 mA	0–100 mA
AC Input			115 Vac ±10%, 48–63 Hz; 0.6 A, 55 W at 115 Vac For 230 Vac see Option 028	115 Vac ±10%, 48–63 Hz; 0.6 A, 55 W at 115 Vac For 230 Vac see Option 028	115/230 Vac, 48–63 Hz 0.9 A, 90 W at 115 Vac 115/230 Vac switch
Constant Current Remote Programming	Voltage Control (Accuracy: 0.5% of output current +.04% of range)	Range A	200 mV/mA	1 V/mA	10 V/mA
		Range B	20 mV/mA	100 mV/mA	1 V/mA
		Range C	2 mV/mA	10 mV/mA	100 mV/mA
	Resistance Control (Accuracy: 1% of output control +.04% of range)	Range A	400 ohms/mA	2K ohms/mA	10K ohms/mA
		Range B	40 ohms/mA	200 ohms/mA	1K ohm/mA
		Range C	4 ohms/mA	20 ohms/mA	100 ohms/mA
Voltage Limit Remote Programming	Voltage Control (Accuracy: 20%)		1 V/V	1 V/V	1 V/V
	Resistance Control		870 ohms/V	440 ohms/V	820 ohms/V
	Accuracy		20%	20%	15%
Output Impedance (R in parallel with C)*		Range A	R = 330 Meg, C = 500 pF	R = 1330 Meg, C = 10 pF	R = 10,000 Meg, C = 900 pF
		Range B	R = 33 Meg, C = 0.005 μF	R = 133 Meg, C = 100 pF	R = 1,000 Meg, C = 700 pF
		Range C	R = 3.3 Meg, C = 0.05 μF	R = 13.3 Meg, C = 1000 pF	R = 100 Meg, C = 1500 pF
Ripple and Noise: rms/p-p (dc to 20 MHz) Either output terminal can be grounded		Range A	0.40 μA rms/5 μA p-p	0.20 μA rms/0.5 μA p-p	50 μA rms/2 μA p-p
		Range B	4.0 μA rms/40 μA p-p	2.0 μA rms/7.5 μA p-p	0.5 μA rms/25 μA p-p
		Range C	40 μA rms/250 μA p-p	20 μA rms/100 μA p-p	5 μA rms/500 μA p-p
Programming Speed: from 0 to 99% of range switch setting with a resistive load. **(Output Current Modulation)			500 μs	500 μs	1 ms
Meter Ranges (Accuracy 2% of full scale)			6, 60, 600 mA; 60 Vdc	3, 30, 300 mA; 120 Vdc	1.2, 12, 120 mA; 360 Vdc
Price			$475	$475	$600

*This network is a simplified representation of a complex network. The formula $Z = RX_C/\sqrt{R^2 + X_C^2}$ is used for frequencies up to 1 MHz by substituting the values given for R and C. Above 1 MHz, the output impedance is greater than the formula would indicate—load transient overhoots are less than 20% of range setting for a full load change with a 1μ sec. rise time.
**Output current can be modulated 100% up to 100 Hz; percent moduation desreases linearly to 10% at 1000 Hz.

OPTIONS AND ACCESSORIES
Increase DC Power Supplies Versatility
Models 14513A-14545A

Options are customer-requested, factory-performed modifications to standard instruments. A list of all options available on Hewlett-Packard dc power supplies is given below. To determine which options are available for a particular supply, refer to the appropriate product page.

Options

001: 208 V ac ±10%, 3-phase input, 57-63 Hz, no charge.

002: 230 V ac ±10%, 3-phase input, 57-63 Hz, no charge.

003: 460 V ac ±10%, 3-phase input, 57-63 Hz. 6464C, 6466C, 6469C, 6472C, 6475C, 6477C, 6479C, 6483C, $200; all other models, no charge.

005: 50 Hz ac input. 6110A, 6516A, $50. 6453A, 6456B, 6459A, 712C, $25. 6464C, 6466C, 6469C, 6472C, 6475C, 6477C, 6479C, 6483C, no charge; all other models, $10.

006/011: internal overvoltage protection crowbar. Refer to product pages for prices.

007: ten-turn output voltage control. 6205B, 6227B, 6228B, 6253A, 6255A, $50; all other models. $25.

008: ten-turn output current control. 6227B, 6228B, 6253A, 6255A, $50; all other models, $25.

009: ten-turn output voltage and current controls. Consists of Options 007 and 008 on same instrument. 6227B, 6228B, 6253A, 6255A, $90; all other models, $45.

010: chassis slides. Attached to supply at factory. 6253A, 6255A, 6427B, 6428B, 6433B, 6434B, 6438B, 6439B, 6443B, 6448B, $125. 6453A, 6456B, 6459A, $195; all other models. $50.

013: three-digit graduated decadial voltage control. Includes single 10-turn control. 6205B, 6227B, 6228B, 6253A, 6255A, $120. 6207B, 6209B, 6220B, 6224B, 6226B, 6294A, 6299A, 6515A. $35; all other models, $60.

014: three-digit graduated decadial current control. Includes single 10-turn control. 6227B, 6228B, 6253A, 6255A, $120. 6220B, 6224B, 6266B, $35; all other models, $60.

016: 115 V ac ±10%, 1-phase input. Factory modification replaces 230 V transformer with 115 V transformer, $75.

017: 208 V ac ±10%, 1-phase input. Modification replaces 115 or 230 V transformer with 208 V transformer, $75.

018: 230 V ac ±10%, 1-phase input. Modification replaces 115 V transformer with 230 V transformer. 6110A, 6282A, 6285A, 6286A, 6290A, 6291A, 6296A, 6516A, $50; all other models, $75.

020: voltage programming adjust. Allows the voltage programming coefficient and zero output voltage to be adjusted via an access hole in the rear panel, $25.

021: current programming adjust. Allows the current programming coefficient and zero output current to be adjusted via an access hole in the rear panel, $25.

022: voltage and current programming adjusts. Consists of Options 020 and 021 on same instrument, $45.

023: rack kit for mounting one 6464C-6483C supply in standard 19" rack, $25.

026: 115 V ac ±10%, single phase input. Factory modification reconnects power transformer (and other components where necessary) for 115 V operation, $10.

027: 208 V ac ±10%, single phase input. Factory modification reconnects power transformer (and other components where necessary) for 208 V operation. 6259B, 6260B, 6261B, 6268B, 6269B, $15; all other models, $10.

028: 230 V ac ±10%, single phase input. Factory modification reconnects power transformer (and other components where necessary) for 230 V operation, $10.

031: 380 V ac ±10%, 3-phase input, 57-63 Hz, $275.

032: 400 V ac ±10%, 3-phase input, 57-63 Hz, $275.

040: interfacing for multiprogrammer operation. Prepares standard Hewlett-Packard supplies for resistance programming by the 6940A Multiprogrammer or 6941A Extender. 6220B, 6224B, 6226B, 6256B, 6259B, 6260B, 6261B, 6263B, 6264B, 6265B, 6266B, 6267B, 6268B, 6269B, 6271B, 6274B, $60; 6101A, 6102A, 6111A, 6112A, 6113A, $30.

Accessories

14513A: rack kit for mounting one 3½" high, half rack (8½" wide) supply, $20.

14515A: rack kit for mounting one 5¼" high, half rack (8½" wide) supply, $23.

14525A: rack kit for mounting two 5¼" high, half rack (8½" wide) supplies, $12.

14523A: rack kit for mounting two 3½" high, half rack (8½" wide) supplies, $10.

14521A: rack kit for three 6211A-6118A supplies, $25.

- **Option J01:** rack kit for mounting two 6211A-6218A supplies (includes one filler panel), $35.
- **Option J02:** rack kit for mounting one 6211A-6218A supply (includes two filler panels), $35.
- **6950A, Option J47:** filler panel for one 6211A-6218A supply. Used with rack kit 14521A, $10.

14545A: set of 4 casters for one 6464C16483C supply, $35.

Specifications definitions

Load regulation: voltage load regulation is given for a load current change equal to the current rating of the supply. Current load regulation is given for a load voltage change equal to the voltage rating of the supply.

Line regulation: given for a 10% change in line voltage at any output voltage and current within rating.

Ripple and noise: stated as rms/p-p (dc to 20 MHz), at any line voltage and under any load condition within rating.

Temperature coefficient: output change per degree Centigrade change in ambient following 30 minutes warm-up.

Stability: total drift in output over 8 hour interval under constant line, load, and ambient after 30 min. warm-up.

Resolution: minimum output voltage or current change that can be obtained using front panel controls.

Output impedance (typical): represented by a resistance in series with an inductance (values in spec tables).

Load transient recovery: time required for output voltage recovery to within specified level of nominal output voltage following a change in output current equal to current rating of the supply or 5 amps, whichever is smaller.

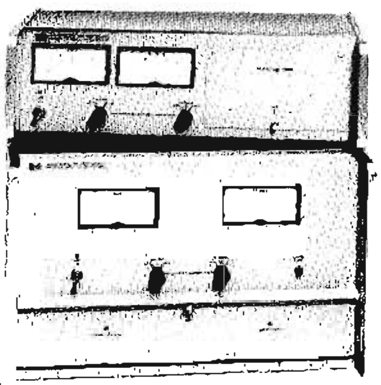
Programming speed: typical time required to non-repetitively program from zero to within 99.9% of the maximum rated output voltage, or from the maximum rated output voltage to within 0.1% of that voltage above zero.

DIGITAL POWER SOURCES

Complete D/A subsystem in one package

Models 6128B-6145A

Voltage sources



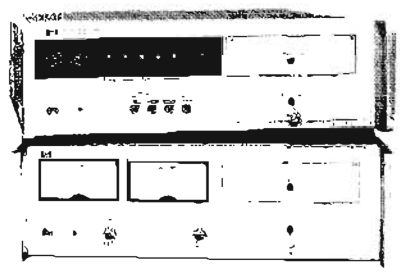
6130B
±50 V, 1 A
6131B
±100 V, 0.5 A

◄NEW

6128B
±16 V, 12.5 A
6129B
±50 V, 5 A

Current sources

NEW ▼



6145A
±100 mA, 100 V
WITH FRONT
PANEL CONTROLS

6140A
±160 mA, 100 V

▲ NEW

Description

Digitally Controlled Power Sources are complete digital-to-analog links between a computer (or other digital source) and any application requiring a fast, accurately settable source of dc or low frequency ac power. Initially, these applications may be thought of as requiring a digital-to-analog converter with augmented output power capability, a digitally controlled power supply, or a digitally controlled waveform synthesizer. However, such applications generally require more than a programmable power supply or the simple tandem combination of a D/A converter and an operational amplifier. Interface circuitry must be added to insure compatability between the computer and the D/A converter, and isolation must be provided between input and output. Other functions required include reference and B+ sources, internal storage to increase computer operating efficiency and minimize programming overshoots, programmable current limiting protection for the output power amplifier and the load, and feedback signals to inform the computer of the voltage source status.

Plug-in cards for the Digitally Controlled Power Sources determine the logic format (BCD or binary), logic sense, and logic levels required to program the instruments. This modular construction provides a variety of standard and special interface options for your present computer, and facilitates modification of your DCPS for use with future computers or other digital data sources.

Digitally Controlled Voltage Sources have programmable current latches and gross current limits to protect the load, whether the instrument is acting as a power source or power sink. Analog input terminals allow an external dc or ac voltage to be summed with the programmed dc voltage.

Digitally Controlled Current Sources have an active guard that minimizes leakage currents between output leads to the unit under test. Model 6145A is equipped with a 4-digit pushbutton current adjust and 1-digit voltage limit control that make the instrument ideal for either bench or systems use as an accurate current source for test, control, and calibration.

General specifications

	6128B	6129B	6130B	6131B	6140A 6145A (BCD Only)
DC OUTPUT:					
Binary Instruments (Option J20, 062, or 064)					
X1 Range	−16.384 to +16.3835V, 12.5A	−16.384 to +16.3835V, 5A	−16.384 to +16.3835V, 1A	−16.384 to +16.3835V, 0.5A	−16.384 to +16.3835mA, 100V
X10 Range	———	−50 to +50V, 5A	−50 to +50V, 1A	−100 to +100V, 0.5A	−163.84 to +163.835mA, 100V
8421 BCD Instruments (Option 061 or 063)					
X1 Range	−9.999V to +9.999V, 12.5A	−9.999V to +9.999V, 5A	−9.999V to +9.999V, 1A	−9.999V to +9.999V, 0.5A	−9.999mA to +9.999mA, 100V
X10 Range	———	−50 to +50V, 5A	−50 to +50V, 1A	−99.99V to +99.99V, 0.5A	−99.99mA to +99.99mA, 100V
RESOLUTION:					
Binary Instruments	X1 Range: 0.5mV		X1 Range: 0.5mV X10 Range: 5mV		X1 Range: 500nA X10 Range: 5µA
8421 BCD Instruments	X1 Range: 1mV		X1 Range: 1mV X10 Range: 10mV		X1 Range: 1µA X10 Range: 10µA

	6128B	6129B	6130B	6131B	6140A 6145A (BCD Only)
BASIC ACCURACY (90 DAYS): Accuracy at 23°C ±3°C, 115 Vac input, no load, following 30 minutes warm-up	X1 Range: 1.5mV	X1 Range: 1.5mV X10 Range: 15mV	X1 Range: 1mV X10 Range: 10mV		X1 Range: 1µA ±.005% X10 Range: 10µA ±.005%
PROGRAMMING TIME: For output to settle within 0.1% of programmed change	350µsec	300µsec			
STABILITY: DC output drift under constant line, load, and ambient temperature for 8 hours after 30 minutes warm-up.					
Binary Instruments	X1 Range: 500µV	X1 Range: 500µV X10 Range: 2.5mV		X1 Range: 500µV X10 Range: 5mV	X1 Range: 500nA X10 Range: 5µA
8421 BCD Instruments	X1 Range: 300µV	X1 Range: 300µV X10 Range: 1.5mV		X1 Range: 300µV X10 Range: 3mV	X1 Range: 500nA X10 Range: 5µA
RIPPLE AND NOISE: At any line & load condition within rating	20mV p-p 8mV rms	12mV p-p 3mV rms	7mV p-p 3mV rms		p-p / rms X1 Range: 2µA / 0.5µA X10 Range: 8µA / 2µA

Weight

6128B, 6129B: net, 72 lbs (33 kg); shipping, 78 lbs (35 kg).
6130B, 6131B: net, 32 lbs (15 kg); shipping, 48 lbs (22 kg).
6140A, 6145A: net, 45 lbs (20 kg); shipping, 52 lbs (24 kg).

Dimensions

6128B, 6129B: 16¾″ wide, 10½″ high, 21⅜″ deep (42,55 x 26,67 x 54,3 cm).
6130B, 6131B: 16¾″ wide, 5¼″ high, 15⅝″ deep (42,55 x 13,34 x 39,69 cm).
6140A, 6145A: 16¾″ wide, 5¼″ high, 19½″ deep (42,55 x 13.34 x 49,40 cm).

AC power Input

6128B, 6129B: 115/230 V ac, 48-63 Hz; 6.4 A, 780 W @ 115 V ac; 115/230 V ac switch-selected.
6130B, 6131B: 115 V ac ±10%, 48-440 Hz; 1.2 A, 100 W.
6140A, 6145A: 115/230 V ac, 48-440 Hz; 1.2 A, 100 W @ 115 V ac; 115/230 V ac switch-selected.

Cooling

6130B, 6131B are convection cooled.
6128B, 6129B, 6140A, 6145A are forced air cooled.

Software for Hewlett-Packard computers

(Refer to Hewlett-Packard programs catalog for prices, descriptions and ordering information).
14902 BCS Driver for HP DCPS
14903 Verification Routine for HP DCPS
14914 DOS/DOS-M Driver for HP DCPS

Accessories available

14533B Pocket Programmer and 14534A Pocket Programmer 3-foot extension cable permits manual control for off-line service and manual calibration. **Prices:** 14533B, $97; 14534A, $50.

14535A HP Computer Interface Kit includes 12661A computer I/O card, 14539A cable, verification software and BCS driver. Up to eight DCPS's may be controlled from one 14535A.
Price: $1250.

14536A Chaining Cable connects an additional DCPS to the existing chain of DCPS's. **Price:** $150.

14539A Cable connects the first DCPS in a chain of up to eight instruments to the 12661A DVS programmer card for Hewlett-Packard computers. **Price:** $150.

14544A Cable connects a DCPS to a DEC PDP-8/I computer. Includes instructions for constructing the interface from DEC logic modules. **Price:** $150.

Price: Model 6128B, 6129B, $2700. Models 6130B, 6131B, $1800. Model 6140A, $2500. Model 6145A,[1] $2750.
Note: standard or special option must be specified.

Standard options: (no additional charge, except for Option 028).
028: transformer tap change for 230 V ac ±10%, single phase input on 6130B and 6131B. **Price:** $10.
J20: binary interface for 12661A DVS programmer I/O card for Hewlett-Packard computers.
061: BCD interface for NPN open collector circuits.
062: binary interface for NPN open collector circuits.
063: BCD interface for microcircuit logic levels.
064: binary interface for microcircuit logic levels.

Special options: if none of the standard interface options meet your requirements, quotations for special options may be obtained from your Hewlett-Packard field engineer.

[1] No standard options are available on Model 6145A which has BCD microcircuit logic levels.

Model 6933B D/A Converter

The Model 6933B Digital-Analog Converter is a complete D/A subsystem in one package. It is similar to the Models 6128B, 6129B, 6130B, and 6131B Digitally Controlled Power Sources except for its lower output rating (±10 V at 0-10 mA BCD; ±16 V BIN) and the elimination of the programmable current latch feature.

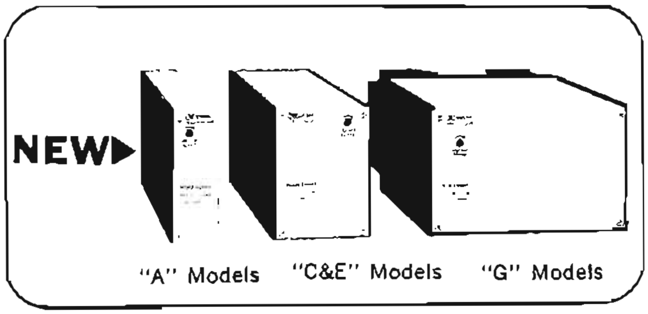
Price: $1500. Standard or special option must be specified.

Standard options: Options J20, 061, 062, 063, and 064 are the same as described for Models above and are available at no charge.

Special options: quotations for special options may be obtained from your Hewlett-Packard field engineer.

6933B

MODULAR POWER SUPPLIES
44 Models/3-48V/to 192W Output
Models 62003A-62048G



Description

Models 62003A-62048G include forty-four modular power supplies covering eleven of the most often used voltage ratings. Output voltage ratings are from 3 to 48 volts, with four output current ratings available at each voltage. For example, at 5 volts there are 2.0, 4.0, 8.0, and 16.0 ampere supplies available. Each nominal output voltage is adjustable over a ±0.5 V or ±5% range (whichever is greater), by means of a front-panel accessible screwdriver control. All supplies deliver full output from 0 to 50°C, with linear derating by only 50% at 71°C. To supplement the standard output ratings, additional output ratings are also available on a special handling basis.

These series-regulated supplies contain several protective features including cut-back type current limiting, over-temperature protection, protected remote sensing, and reverse voltage/reverse current protection. Overvoltage protection is available as a built-in option.

The units are packaged in three uniform height and depth cases which are fractions of a standard 19-inch rack width: ⅛ width, ¼ width, and ½ width. Combinations of the three packages can be mounted in an accessory rack mounting tray, or the supplies can be mounted individually. Additional rack-mounting accessories and available options are described on page 206.

Specifications
Performance

Load regulation: less than 0.01% or 1 mV, whichever is greater, for a no load to full load (or vice versa) change in output current.

Line regulation: less than 0.01% or 1 mV, whichever is greater, for change in ac input voltage from 104 to 127 V ac. (For 220 V and 240 V operation, the ac input voltage is from 190 to 233 V, or 208 to 254 V.

Ripple and noise: less than 1 mV rms, 2 mV p-p (20 Hz to 20 MHz).

Temperature coefficient: less than 0.01%/°C over the temperature range from 0 to 50°C.

Stability: 0.1% total drift in dc output voltage over 8-hour interval.

Load transient recovery: output voltage recovers to within 15 mV of nominal output voltage in 50 μs following a load change from full to half load (or vice versa).

General

AC input power: 104-127 V ac, 48-63 Hz, single phase. See Options 101, 102, and 103 on page 205 for other line voltage ratings available.

Storage temperature: −55°C to +85°C.

Operating temperature: 0 to 50°C ambient. Output current is linearly derated to 50% of maximum at 71°C ambient.

Cooling: convection cooled.

DC output isolation: output is isolated; either output terminal may be grounded.

Dimensions:
- **A-suffix Models:** 1.91″ W x 5.03″ H x 12.25″ D.
- **C- & E-suffix Models:** 3.94″ W x 5.03″ H x 12.25″ D.
- **G-suffix Models:** 8.11″ W x 5.03″ H x 11.50″ D.

Weight (net/shipping):
- **A-suffix Models:** 6 lbs (2,7 kg)/8 lbs (3,6 kg).
- **C-suffix Models:** 10 lbs (4,5 kg)/12 lbs (5,4 kg).
- **E-suffix Models:** 13 lbs (5,9 kg)/16 lbs (7,3 kg).
- **G-suffix Models:** 21 lbs (9,5 kg)/25 lbs (11,3 kg).

Options

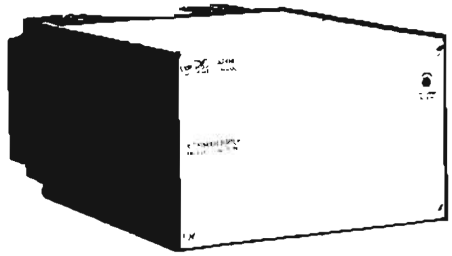
Refer to page 205 for complete list of options.

Output ratings

DC OUTPUT		MODEL	PRICE*
NOMINAL VOLTAGE (Minimum Adj. Span)	CURRENT AT 50°C		
3V (±0.5V)	2A	62003A	$89
	4.25A	62003C	$125
	8.5A	62003E	$145
	17A	62003G	$195
4V (±0.5V)	2A	62004A	$89
	4A	62004C	$125
	8A	62004E	$145
	16A	62004G	$195
5V (±0.5V)	2A	62005A	$89
	4A	62005C	$125
	8A	62005E	$145
	16A	62005G	$195
6V (±0.5V)	1.75A	62006A	$89
	3.75A	62006C	$125
	7.5A	62006E	$145
	15.0A	62006G	$195
10V (±0.5V)	1.5A	62010A	$89
	3.25A	62010C	$125
	6.5A	62010E	$145
	13.0A	62010G	$195
12V (±0.60V)	1.5A	62012A	$89
	3.0A	62012C	$125
	6.0A	62012E	$145
	12.0A	62012G	$195
15V (±0.75V)	1.25A	62015A	$89
	2.5A	62015C	$125
	5.0A	62015E	$145
	10.0A	62015G	$195
18V (±0.90V)	1.0A	62018A	$89
	2.25A	62018C	$125
	4.5A	62018E	$145
	9.0A	62018G	$195
24V (±1.20V)	.75A	62024A	$89
	1.75A	62024C	$125
	3.75A	62024E	$145
	7.5A	62024G	$195
28V (±1.40V)	.7A	62028A	$89
	1.5A	62028C	$125
	3.25A	62028E	$145
	6.5A	62028G	$195
48V (±2.40V)	.45A	62048A	$89
	1.0A	62048C	$125
	2.0A	62048E	$145
	4.0A	62048G	$195

*OEM pricing is available to original equipment manufacturers. Contact your local Hewlett-Packard sales office.

MODULAR POWER SUPPLIES
9 Models, 4-28V/to 300W Output
Models 62604J-62628J



NEW 62604J-62628J

Description

Models 62604J-62628J are transistor switching-regulated power supplies whose dc outputs include nine of the most often used voltage ratings. Output voltage ratings are from 4 V to 28 V. Each nominal output voltage is adjustable over a ±0.5 V or ±5% range (whichever is greater), by means of a front-panel accessible screwdriver control. All supplies deliver full output from 0 to 50°C, with linear derating by only 50% at 71°C.

Overvoltage, overcurrent, overtemperature, protected remote sensing, and reverse voltage protection are standard features of all models.

An advanced 20 kHz transistor switching design is employed in these units. The design takes full advantage of the foremost virtue of the switching regulator, namely efficiency, while holding down ripple and noise to levels that are compatible with most low-voltage applications including computer mainframes, digital systems, and systems for industrial process automation. At operating efficiencies up to 80%, a relatively small percentage of power is converted to heat. This permits the use of a compact package while at the same time reducing heat generation that may affect other system components.

Units are packaged in a standard 5" H x 8" W x 11½" D case. They may be used alone, in buried applications, or combined with other 62000 series supplies using an accessory rack mounting tray. A couplete line of rack mounting accessories is described on page 206.

Specifications

Performance

Load regulation: less than 0.15% for a load change from 0 to 15% of rated output, and less than 0.10% for a change from 15% to 100% of rated output.

Line regulation: less than 0.10% for a change in ac input voltage from 104 to 127 V ac. (For 220 V and 240 V operation, the ac input voltage is from 190 to 233 V or 208 to 254 V, respectively.)

Ripple and noise: less than 20 mV rms, 30 mV p-p (20 Hz to 20 MHz).

Temperature coefficient: less than 0.02%/°C over the temperature range from 0 to 50°C.

DC output ratings

Model	DC Output	
	Nominal voltage (Minimum adj. span)	Current at 50°C
62604J	4 V (±0.5 V)	40.0 A
62605J	5 V (±0.5 V)	40.0 A
62606J	6 V (±0.5 V)	33.0 A
62610J	10 V (±0.5 V)	25.0 A
62612J	12 V (±0.6 V)	23.0 A
62615J	15 V (±0.75 V)	20.0 A
62618J	18 V (±0.90 V)	16.7 A
62624J	24 V (±1.20 V)	12.5 A
62628J	28 V (±1.40 V)	10.7 A

Stability: less than 0.1% total drift in dc output voltage over 8-hour interval.

Transient recovery: less than 1 ms for output voltage recovery to within 0.3% of setting following a load change from 100% to 50% or 50% to 100%.

Overshoot: turn-on transient is within regulation and ripple band. Turn-off is smooth exponential decay.

Carry-over time: output voltage remains within 2% of specified nominal for a minimum of 30 ms under full load following removal of ac input power.

General

AC input power: 104-127 V ac, 48-440 Hz, single phase. See Options 101 and 102, on this page for other line voltage ratings available.

Storage temperature: −55°C to +85°C.

Operating temperature: 0 to 50°C ambient. Output current for continuous operation is derated linearly from full output at 50°C to 50% of output at 71°C.

Cooling: convection cooled.

Dimensions: 8.14" W x 5.03" H x 11.50" D (207 mm W x 127 mm H x 292 mm D).

Weight: (net/shipping): 13 lbs (6,6 kg)/14.5 lbs (8,2 kg).

Price: Models 62604J-62628J, $395.

(Quantity and OEM discounts are available. Contact your local Hewlett-Packard sales office.)

Options

(All options apply to Models 62003A-62048G; only options 101 and 102 apply to Models 62604J-62628J.)

011, adjustable internal overvoltage protection crowbar $30.

101, 190-233 V ac (220 V ac nominal) input .....No charge

102, 208-254 V ac (240 V ac nominal) input .....No charge

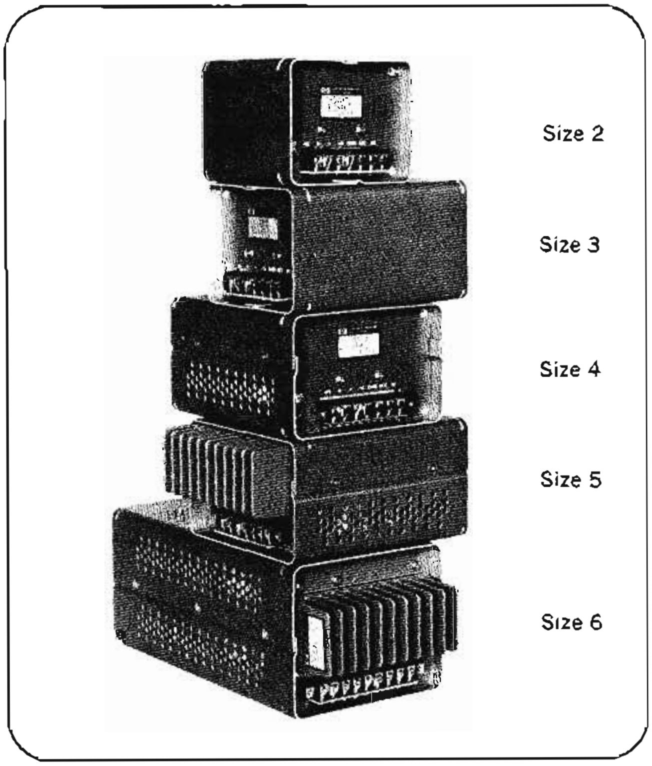
103, 104-127 (208-254 V ac field changeable) input $25

104, includes overvoltage protection crowbar circuit, plus: (1) external crowbar input; (2) output pulse initiated by crowbar condition; (3) access to summing junction for remotely programming power supply to zero ±15 mV ...$40

MODULAR POWER SUPPLIES

6, 12, & 24V single output/±15V dual output

Models 60063A-60246B, 60153D, 60155C



Output ratings

Model	DC output			
	Nominal Voltage (Vdc)	Current (Adc)	Size	Price*
60063A	6 ± 10%	1.5	3	$ 87
60065A	6 ± 10%	3	5	110
60066A	6 ± 10%	8	6	197
60122B	12 ± 10%	0.5	2	72
60123B	12 ± 10%	1	3	79
60125B	12 ± 10%	2.2	5	100
60126B	12 ± 10%	6	6	179
60242B	24 ± 10%	0.25	2	72
60243B	24 ± 10%	0.5	3	79
60244B	24 ± 10%	1	4	88
60245B	24 ± 10%	1.5	5	100
60246B	24 ± 10%	3.5	6	179
60153D	±15 ± 10%	0 – 0.2	3	97
60155C	±15 ± 10%	0 – 0.75	5	133

*Quantity and OEM discounts are available. Contact your local Hewlett-Packard sales office.

Overall dimensions:

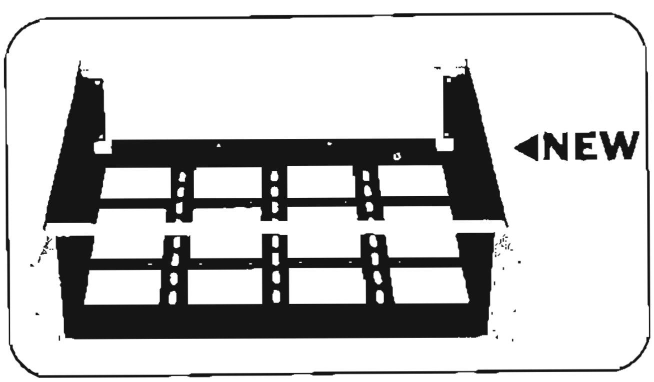
Size	Mounting face	Module length
2	3⅜" (86 mm) x 4⅛" (105 mm)	4⅛" (105 mm)
3	3⅜" (86 mm) x 4⅛" (105 mm)	6" (152 mm)
4	3⅜" (86 mm) x 5⅛" (130 mm)	6" (152 mm)
5	3⅜" (86 mm) x 5⅛" (130 mm)	7-5/16" (186 mm)
6	4¼" (108 mm) x 5⅛" (130 mm)	11" (279 mm)

Description

These single and dual output modular supplies are intended for applications requiring a fixed constant voltage source of dc. The nominal output voltage is regulated to 0.05% and may be offset from the design center by up to ±10%. All supplies are short circuit proof and will not be damaged by overload.

Accessories for 62000 Series Modular Power Supplies

Rack mounting tray, Model 62410A: for rack mounting any combination of modular supplies totaling a full unit rack width or less. Size 19" wide, 5¼" high, 17" deep. Includes detachable handles, but without front panel. **Price:** $65.



Rack mounting tray cooling unit, Model 62413A: provides filtered room temperature air at 45 CFM to rack tray. Suggested when tray is mounted in rack with inside temperature over 50°C or for confined installations that would otherwise restrict natural convection cooling. 19" wide, 1¾" high, 17" deep. 120/220/240 volts, 50/60 Hz. **Price:** $125.

Rack tray blank front panel, Model 62411A: provides blank front cover for rack mounting tray. **Price:** $12.

Rack tray blank rear panel, Model 62412A: permits customer to install own input/output connectors or other hardware. **Price:** $15.

Rack tray ac distribution panel, Model 62415A: mounts on rear of rack mounting tray; includes ac input terminal strip and line cord. **Price:** $25.

Rack tray slides, Model 62414A: provides easy access to rack-mounted tray of supplies. **Price:** $50.

Complete power systems: Hewlett-Packard will produce complete power systems, including modular power supplies, custom front and rear panels, and other desired accessories in accordance with custom requirements on a special handling basis. Contact your local Hewlett-Packard field engineer for further information.

X-Y recorders

The Cartesian coordinate graph is one of the most effective methods for presenting related data clearly. As a result, X-Y recorders have found wide application in areas from general purpose laboratory use to a specialized system readout.

Applications

X-Y recorders are frequently used for the recording of spectra, since the sweeping device need not have a linear sweep as a function of time. Hewlett-Packard sweepers and spectrum analyzers—from audio through microwave—produce outputs directly compatible with Hewlett-Packard X-Y recorders. Sampling devices, such as fault locators, real-time spectrum analyzers, sampling oscilloscopes and time domain reflectometers benefit from the signal averaging caused by the null detection recording method used in all Hewlett-Packard X-Y recorders, reducing the effect of wideband noise. The final graph is significantly more accurate, precise and easier to reproduce than oscilloscope photos of the same event. An X-Y recorder is indispensable when permanent records are needed for such X vs. Y data as semiconductor device curves, hysteresis charts, or records of physical variables such as pressure vs. temperature.

Recorders are extremely effective where precise X-Y plots are needed, either to obtain accurate data or to allow rapid interpretation of data. An X-Y recorder automatically and conveniently plots the value of an independent variable versus a dependent variable, directly on conventional graph paper, working from readily derived electrical signals.

Basic operation of X-Y recorders

The precision needed for accurate X-Y graphs is accomplished in Hewlett-Packard recorders by the use of physically and electrically linear feedback elements (often called slidewires) coupled directly to the marking pen and the X-axis arm. Both X and Y axis slidewires are physically mounted along the traveling paths of the arm and pen carriage, avoiding any error-producing mechanical linkages.

The feedback generated from these slidewires is a voltage directly proportional to the position of the pen with respect to the "zero" position originally chosen. This voltage is balanced against the signal input by a differential amplifier. The output of the amplifier drives the pen motors, and the pen, until a null balance condition is reached. The accuracy of the final graph, then, is determined by the linearity of the slidewire and the ability of the servo system to drive the pen to the exact point desired (also called repeatability, deadband or resettability). Hewlett-Packard specifications include such potential errors in a single accuracy specification.

X-Y recordings may also be made from computer-generated data or other digital devices by the 7591A Point Plotting System or the 7200 series Graphic Plotters. The 7591A accepts analog inputs through an external D/A converter or from analog outputs from systems such as Hewlett-Packard multichannel analyzers; the 7200 series receives data directly in digital form. Both plotters are compatible with HP 2100 series computers. X-Y plotters are also available for use with HP 9800 series calculators.

Writing system

Most Hewlett-Packard recorders utilize a self-contained disposable pen/ink system which allows quick, easy pen changes for renewal or color change. Red, blue, green and black colors are available, and interchangeable between recorders using disposable pens.

Autogrip paper holddown

Any graph paper may be used on Hewlett-Packard X-Y recorders, up to the 8½" x 11" or 11" x 17" maximum size of the recorder chosen. Paper is held to the recording surface electrostatically with the Autogrip holddown system, which grips any paper tightly and silently without vacuum pumps or mechanical clips.

Selecting an X-Y recorder

Hewlett-Packard X-Y recorders are available in 2 basic chart sizes. Since all recorders will handle 8½" x 11" paper, this choice must be determined by instrument size requirement or cost. Laboratory general-purpose recorders are available in both paper sizes, in single or two pen versions, and with built-in or plug-in preamplifiers. All recorders are available with metric or English scaling.

Other selection considerations are sensitivity, speed and acceleration, or the need for an automatic chart advance. Also available are models for OEM or other dedicated applications. These are designed so that customized systems can be made in a production environment, and are available with functional discounts to OEM purchasers.

Hewlett-Packard X-Y Recorders

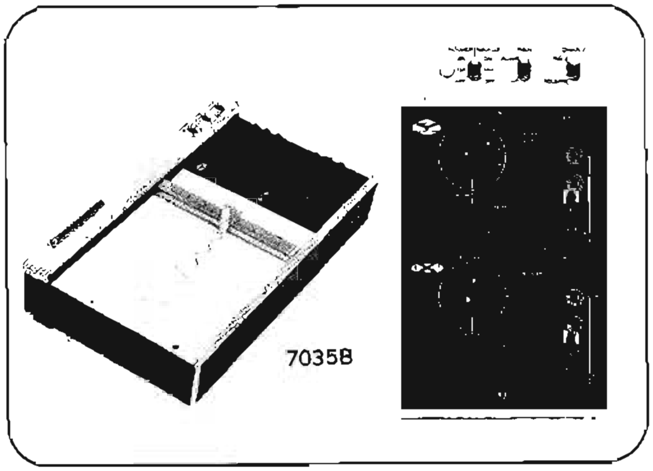
Description	Model	Chart Size (in.)	Page	Maximum Sensitivity (mV/in.)	Other	Price
General Performance	7035B	8½ x 11	208	1.0	External Time Base Available	$ 985
	136A	8½ x 11	216	0.5	Two Pen, Time Base Standard	2850
	7001A	11 x 17	216	0.1	Time Base Standard	2275
High Performance	7004B	11 x 17	209	0.5[1]	Uses Plug-ins	1445[1]
	7034A	8½ x 11	209	0.5[1]	Uses Plug-ins	1295[1]
	7044A	11 x 17 and A3	214	0.5	— —	1350
	7045A	11 x 17 and A3	214	0.5	— —	1675
	7046A	11 x 17 and A3	215	0.5	Two Pen	2650
OEM	7040A	11 x 17 and A3	213	0.5	Single Sensitivity,	890
	7041A	11 x 17 and A3	213	0.5	Selected by option	1050
Specialized	7200 Series	11 x 17	470		Computer Graphics	3300-3575
	9862A	11 x 17			For 9800 Series Calculators	2675

[1] Depends on plug-in selection.

GENERAL PURPOSE X-Y RECORDERS

Low cost

Models 7035B and 17108A



7035B

The Model 7035B is a low cost, solid-state X-Y Recorder for general purpose applications. Each axis has an independent servo system with no interaction between channels. The recorder graphs two related functions from two dc signals representing the functions. The ultra-compact design is convertible to rack mounting by addition of two wing brackets (supplied). Metric scaling and calibration are optional.

The input terminals accept either open wires or plug-type connectors. Five calibrated ranges from 1 mV/in. to 10 V/in. are provided in each axis. A variable range control permits scaling of signal for full scale deflection. Standard features include high input impedance (one megohm on all but the first two ranges), floated and guarded signal pair input, 0.2% accuracy, Autogrip electric paper holddown, electric pen lift, adjustable zero set, lockable zero and variable range controls, and rear input connector. A plug-in time base (Model 17108A) operates on either axis to provide five sweep speeds from 0.5 to 50 s/in.

Each closed-loop servo system employs a high-gain solid-state servo amplifier, Hewlett-Packard servo motor, long-life balance potentiometer, photochopper, low pass filter, guarded inputs, precision attenuator and balance circuit. Designed for easy maintenance, most components are mounted on a printed circuit board and accessible by removing only the rear cover. Both balance potentiometers are accessible for inspection or cleaning by removing a snap-on strip.

Performance specifications

Input ranges: English: 1, 10, 100 mV/in.; 1 and 10 V/in.; **Metric:** 0.4, 4, 40, 400 mV/cm and 4 V/cm. Continuous vernier between ranges.

Type of inputs: floated and guarded signal pair; rear input connector.

Input resistance:

Range		Input resistance
1 mV/in.	(0.4 mV/cm)	Potentiometric (essentially infinite at null)
Variable		11 kΩ
10 mV/in.	(4 mV/cm)	100 kΩ
Variable		100 kΩ
100 mV/in.	(40 mV/cm)	1 MΩ
Variable		1 MΩ
1 V/in.	(400 mV/cm)	1 MΩ
Variable		1 MΩ
10 V/in.	(4 V/cm)	1 MΩ
Variable		1 MΩ

Input filter: >30 dB at 60 Hz; 18 dB/octave above 60 Hz.

Maximum allowable source impedance: no restrictions except on fixed 1 mV/in. (0.4 mV/cm) range. Up to 20 kΩ source impedance will not alter recorder's performance.

Accuracy: ±0.2% of full scale.

Linearity: ±0.1% of full scale.

Resettability: ±0.1% of full scale.

Zero set: zero may be set up to one full scale in any direction from zero index. Lockable zero controls.

Slewing speed: 20 in./s, 50 cm/s nominal at 115 V.

Interference rejection: conditions for the following data are line frequency with up to 1 kΩ between the negative input and guard connection point.

Range		DC (CMR)	AC (CMR)
English	Metric		
1 mV/in.	0.4 mV/cm	130 dB	100 dB
10 mV/in.	4 mV/cm	110 dB	80 dB
100 mV/in.	40 mV/cm	90 dB	60 dB
1 V/in.	400 mV/cm	70 dB	40 dB
10 V/in.	4 V/cm	50 dB	20 dB

General specifications

Paper holddown: Autogrip electrostatic paper holddown grips any chart up to size of platen.

Pen lift: electric pen lift capable of being remotely controlled.

Dimensions: 10-15/32" high, 17½" wide, 4¾" deep (266 x 445 x 121 mm).

Weight: net, 18 lb (8 kg); shipping, 24 lb (10,9 kg).

Power: 115 or 230 V ±10%, 50 to 60 Hz, approximately 45 VA.

Price: Model 7035B — $ 985

Options:

001: Metric calibration — N/C

003: Retransmitting potentiometer on X-axis 5 kΩ ±3% — $ 75

17108A Time Base

17108A

The 17108A is a self-contained external time base designed to plug directly into the input terminals of the 7035B and operate on either axis. An adapter supplied allows the use with a variety of Hewlett-Packard recorders. Any number of recorders may be driven simultaneously, provided the combined parallel input resistance is 20 kΩ or more.

Specifications

Sweep speeds: 0.5, 1, 5, 10, 50 s/in. (0.2, 0.4, 2, 4, 20 s/cm.

Accuracy: 5% of recorder full scale.

Linearity: 0.5% of full scale (20°C to 30°C).

Output voltage: 0 to 1.5 V.

Power: replaceable mercury battery (100 hr).

Price: 17108A — $ 175

17108AM (metric) — $ 175

HIGH PERFORMANCE
Plug-in versatility and fast response
Models 7004B and 7034A

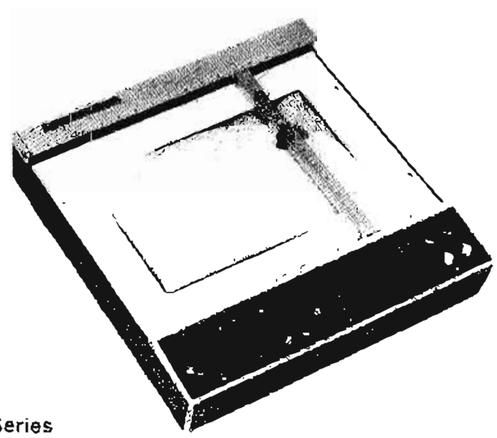
The 7004B and the 7034A are flexible to meet the constantly changing requirements of laboratory measurements. Plug-in modules and a variety of accessories form a versatile high-performance X-Y Recorder. Circuitry common to all plug-in modules (power supplies, interfaces, etc.) is located in the main frame. This allows the user to purchcase additional low-cost plug-ins to expand the measurement capabilities of the system. The plug-in approach allows the user to purchase only the capabilities required.

With an acceleration of more than 1500 in./s², and slewing speed of 30 in./s, the 7004B and 7034A record more phenomena than earlier X-Y recorders.

These recorders use the most advanced technology available. They use all-silicon integrated circuitry and the proven Autogrip electrostatic paper holddown.

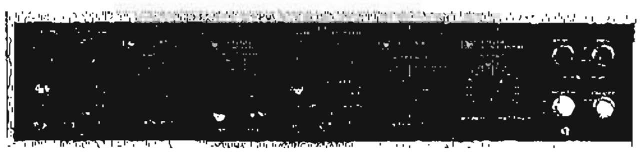
Guarded input circuits are provided to utilize the superior performance fully. Guarding eliminates the effects of unwanted ac and dc common-mode voltages which can be troublesome in low level recording signals from thermocouples, strain gages and similar sources.

Plug-in modules provide a versatile X-Y Recorder for a variety of applications. If your application changes, the needed measurement capability is available by simply adding an inexpensive plug-in. In addition to these advantages, their high dynamic performance allows recorders to be used in practically any X-Y Recorder application.



7004B Series
11 in. x 17 in.

7034A Series
8½ in. x 11 in.



Performance specifications

Number of plug-ins: frame will accept the equivalent of four single-width plug-ins, two per axis.

Type of input: floating and guarded signal pair. Available at the front panel or at the rear connector.

Zero set: zero may be set ±1 full scale from zero index.

Zero check switches: pushbutton zero check switch in each axis allows verification of recorder's zero position without removal or shorting of the input signal.

Mainframe accuracy: 0.2% of fs.

Range vernier: lockable, covers 2.5 times range setting.

Slewing speed: more than 30 in./s (75 cm/s) independent of line voltage and frequency.

Acceleration: more than 1500 in./s² (3800 cm/s²).

Reference stability: better than 0.003%/°C.

Terminal based linearity: ±0.1% of fs.

Resettability: ±0.05% of fs.

General specifications

Paper holddown: Autogrip paper holddown grips charts of any size up to size of platen.

Pen lift: local and remote control (contact closure or TTL).

Dimensions: 7004B: 17½″ wide, 17½″ high, 4¾″ deep (445 x 445 x 121 mm). 7034A: 17½″ wide, 10½″ high, 4¾″ deep (445 x 267 x 121 mm).

Weight: 7004B: net, 28 lbs (12,7 kg); shipping, 42 lbs (19,0 kg). 7034A: net, 16 lbs (7,3 kg); shipping, 31 lbs (14,1 kg).

Power: 115 or 230 volts ac ±10%, 50 to 400 Hz, approximately 85 VA (depending on the plug-ins used).

Price

Model 7004B—11″ x 17″	$1445
Model 7034A-8½″ x 11″	$1295

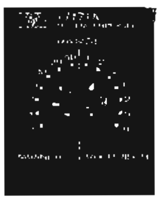
Options

001	Metrically scaled and calibrated	N/C
002	X-axis retransmitting potentiometer, 5 kΩ ±0.1% linearity (7004B only)	$ 75
004	Power supply for 17005-04 incremental chart advance (7004B only)	$ 50

PLUG-IN MODULES
For recorder Models 7004B and 7034A

DC Coupler
Model 17170A

The DC Coupler couples the input signal to the recorder main frame. The input signal range of 100 mV/in (50 mV/cm) may be adjusted to 250 mV/in (125 mV/cm) with a vernier control on the recorder front panel.



DC Amplifier
Model 17171A

The DC Pre-amplifier is a stable, low noise, dc amplifier. The 14 calibrated input ranges are supplemented by a vernier control on the recorder front panel to provide a continuously variable range from 0.5 mV/in. (0.25 mV/cm) to 25 V/in. (12.5 V/cm).

Time Base
Model 17172A

The Time Base plug-in makes X-T or Y-T recordings possible. It employs all-silicon solid-state construction including the latest integrated circuits. Standard features include eight speeds, automatic reset and pen lift at completion of sweep, and remote start control. A vernier control on the recorder front panel extends the sweep speed through 250 s/in. (125 s/cm).

Null Detector
Model 17173A

The Null Detector plug-in provides closed-loop plotting of data in point form, at up to 50 pps. Plotting is accomplished with the Model 17012B/C Point Plotter. The 17012B/C cable plugs into a jack on the 17173A panel and the plotting head is substituted for the recorder pen.

Upon receipt of a seek signal and after the recorder reaches balance, the Null Detector commands the 17012B/C Point Plotter to plot and initiates a plot-complete pulse.

17170A Specifications

Input range: a single fixed calibrated range of 100 mV/in. (50 mV/cm).

Input resistance: constant, 1 MΩ.

Common-mode rejection: 120 dB at dc and 70 dB at 50 Hz and above with 100 ohms between low side and guard connection point with source impedance 10 kΩ or less.

Price: Model 17170A $ 35

17171A Specifications

Input ranges: English: 0.5, 1, 2, 5, 10, 20, 50 mV/in., 0.1, 0.2, 0.5, 1, 2, 5, 10 V/in.; Metric: 0.25, 0.5, 1, 2.5, 5, 10, 25 mV/cm, 0.05, 0.1, 0.25, 0.5, 1, 2.5, 5 V/cm.

Input resistance: 1 MΩ.

Maximum allowable source resistance

Range	Max. Source Resistance
0.5 mV/in. (0.25 mV/cm)	10 kΩ
1 mV/in. (0.5 mV/cm)	20 kΩ
2 mV/in. (1.0 mV/cm)	40 kΩ
5 mV/in. (2.5 mV/cm)	100 kΩ
10 mV/in. (5.0 mV/cm)	200 kΩ
20 mV/in. (10.0 mV/cm)	400 kΩ
50 mV/in. (25 mV/cm) and up	1 MΩ

Common-mode rejection: 120 dB at dc and 100 dB at 50 Hz and above with 100 ohms between low side and guard connection point (at 0.5 mV/in. or 0.25 mV/cm). On other ranges CMR decreases 20 dB per decade step in attenuation.

System accuracy: ±0.2% of full scale.

Zero drift: <1 μV/°C with a maximum of 25 μV from 0 to 55°C.

Price: Model 17171A $ 295

Option: 001 metrically scaled N/C

17172A Specifications

Sweep speeds: English: 0.5, 1, 2, 5, 10, 20, 50, 100 s/in.; Metric: 0.25, 0.5, 1, 2.5, 5, 10, 25, 50 s/cm.

System accuracy: ±1% of full scale on the six fastest ranges, ±2.5% on the remaining two ranges.

Terminal based linearity: ±0.5% of full scale.

Price: Model 17172A $ 225

Option: 001 metrically scaled N/C

17173A Specifications

Plot rate: up to 50 plots/s.

Enable-disable: required disable voltage +3 volts minimum to +20 volts maximum. Required enable voltage: 0 V dc or no connection. Other voltage combinations available on request.

Muting: local or remote.

Plotting accuracy: ±0.25% of full scale.

Input: all inputs, except analog inputs, are available through rear input connectors in the module. Analog inputs are applied to the input terminals of the main frame. Mating connector supplied.

Price: Model 17173A $ 250

Options

001. +3 to +20 V enable, 0 V disable add $ 25
002. −3 to −20 V disable, 0 V enable add $ 25
003. −3 to −20 V enable, 0 V disable add $ 25

DC Offset
Model 17174B

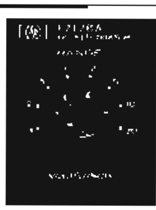
The DC Offset plug-in provides the recorder with the capabilities of recording small signals superimposed on a steady-state dc voltage. The offset plug-in suppresses the steady-state dc voltage allowing recorder sensitivity to be increased.

Filter
Model 17175A

The Filter plug-in rejects ac input signal components. Insertion of the 17175A in front of any other signal conditioning input module will improve normal mode rejection.

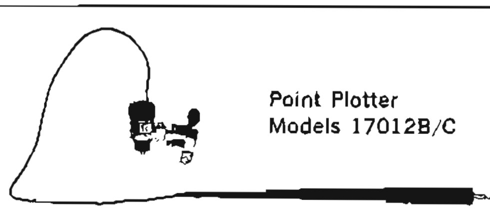
Scanner
Model 17176A

The Scanner plug-in electrically scans between two inputs, similar to the chopped mode on an oscilloscope, and provides the capability of plotting two dependent variables vs. one independent variable. The Scanner plug-in, utilizing the Model 17012B/C high speed point plotter, can scan two selectable inputs (module or main frame) in two scan modes (multiplexing both inputs or singularly). The scan rate is adjustable from 0.1 s/scan to 4 s/scan.



DC Attenuator
Model 17178A

The DC Attenuator offers a stable, passive attenuator with eight ranges. A vernier control on the recorder control panel allows continuously variable settings between fixed ranges of the 17178A.



Point Plotter
Models 17012B/C

17174B Specifications

Offset: less than 1 mV to approximately 1 volt.

Controls: two lockable, ten-turn high resolution controls (less than 1 mV to approximately 10 mV and less than 1 mV to approximately 1 V). An offset polarity switch allows upscale or downscale zero offset.

Offset voltage stability: greater than 0.005%/°C.

Insertion loss: less than 0.05%.

Price: Model 17174B $ 125

17175A Specifications

Input voltage range: −5 to +50 V dc, 10 V ac maximum peak-to-peak.

Maximum source impedance: 1 kΩ, higher impedance decreases filter response.

Rejection: more than 55 dB at 50 Hz and higher (¼ s rise time) or more than 70 dB at 50 Hz and higher (1 s rise time). Front panel selectable.

Insertion loss: 1%; filter may be switched out with no change in insertion loss.

Price: Model 17175A $ 100

17176A Specifications

Input: module input; front panel miniature binding posts isolated from ground (high and low only). Main frame input; utilizes existing input connectors on main frame.

Attenuator: fixed attenuator in decade steps from X1 to X0.001. Variable attenuator provides continuous coverage.

Input impedance: 100 kΩ.

Accuracy: 0.2% of full scale.

Scan rate: adjustable from 0.1 to 4 s/scan.

Price: Model 17176A $ 375

17178A Specifications

Input ranges: English: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20 V/in.; Metric, 0.05, 0.1, 0.25, 0.5, 1, 2.5, 5, 10 V/cm.

Input resistance: 1 MΩ.

Common-mode rejection: 120 dB at dc and 70 dB at 50 Hz and above with 100 ohms between low side and point where the guard is connected (at 100 mV/in. or 50 mV/cm). On other ranges CMR decreases 20 dB per decade step in attenuation.

System accuracy: ±0.2% of full scale.

Price: Model 17178A $ 125

Option: 001 metrically scaled N/C

17012B/C Specifications

The 7004B or 7034A, equipped with the 17012B or 17012C Point Plotter respectively, is capable of point plotting when used with the appropriate plug-in. The 17173A Null Detector plug-in allows rapid point plotting for applications such as a high speed readout for a multichannel pulse height analyzer. The 17176A Scanner plug-in allows plotting of two inputs on a single axis to form a X-Y_1, Y_2 or X_1, X_2-Y recorder.

Plotting rate is up to 50 points per second; power is supplied from the recorder.

Price: Model 17012B (fits Model 7004B) $ 95
Model 17012C (fits Model 7034A) $ 95

RECORDERS & PRINTERS

PLUG-IN MODULE; INCREMENTAL CHART ADVANCE; POINT PLOTTING SYSTEM

AC/DC Converter/DC Preamplifier

AC/DC Converter
DC Preamplifier
Model 17177A

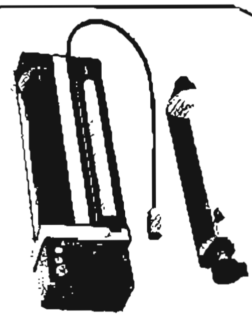
Model 17177A

The 17177A plug-in combines in a single unit the ability to record both dc and ac signals. The average-responding ac mode features an extremely flat frequency response from 5 Hz to 100 kHz. This double-width module may be used in either axis.

Specifications

Input ranges: 5 mV/in. to 20 V/in. (2.5 mV/cm to 10 V/cm) in 1, 2, 5 steps.
Minimum usable input (ac only): ±0.2% of full scale.
Maximum allowable input: 300 V peak.
Type of input: floating and guarded signal pair. Rear inputs not available.
Input impedance: 1 MΩ shunted by less than 40 pF.
Maximum allowable source resistance: 10 kΩ.
Common mode rejection: 80 dB at dc and 50 Hz and above with 100Ω between low side and guard connection point and at 5 mV/in. (2.5 mV/cm). On other ranges CMR decreases 20 dB per decade step in attenuation.
Rise/fall time (ac only, 10-90%)
Slow response (5 Hz to 100 kHz): 2.5 s maximum.
Fast response (50 Hz to 100 kHz): 0.5 s maximum.
Calibration (ac only): responds to average value of input waveform; calibrated in rms value of sine wave.
Accuracy (% of full scale):
dc ±0.5%;
ac (fast response) ±0.25% from 150 Hz to 50 kHz, ±0.5% from 50 Hz to 150 Hz and 50 kHz to 100 kHz;
ac (slow response) ±0.25% from 30 Hz to 50 kHz, ±0.5% from 5 Hz to 30 Hz and 50 kHz to 100 kHz.
Linearity (ac only, % of full scale and above 0.5% of full scale): ±0.25% from 50 Hz to 50 kHz, ±0.35% from 5 Hz to 50 Hz and 50 kHz to 100 kHz.
Warm-up time: 3 minutes nominal.
Zero drift (referred to input): ±30 μV/°C.
Offset: up to one full scale of offset by use of recorder's zero.
Size: double width, occupies both plug-in spaces in axis.
Price: HP 17177A, $600. Option 001 Metric scaled, N/C.

Incremental chart advance
Model 17005A



17005A

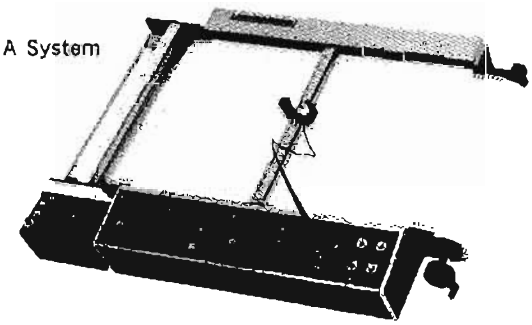
The 17005A is a versatile accessory for the 7001A and 7004B-004. Several types of chart advance modes are offered. The frame advance mode, in which the chart advance permits successive X-Y plots to be made during unattended operation, indexes to within 0.005" (0,13 mm) of the original chart location. The time base mode converts the recorder from X-Y to strip chart recorder operation, while the incremental mode advances the chart in small increments in response to an external signal.

Specifications

Frame advance mode
Advance distance: 24 in (60 cm); time: less than 20 s.
Accuracy: ±0.005 in. (0,0125 cm) non-cumulative.
Time base mode
Speeds: 1, 5, 10, 50, 100 s/in (0.4, 2, 4, 20, 40 s/cm).
Accuracy: ±2%.
Incremental advance mode
Plot density: 200, 100, 50, 20, 10 plots/in. (80, 40, 20, 8, 4 plots/cm).
Max advance rate: 100, 90, 50, 20, 10 plots/s.
Accuracy: ±0.002 in. (0,005 cm) non-cumulative.
Power: supplied by recorder.
Weight: net, 11 lbs (5 kg); shipping, 16 lbs (7,3 kg).

Price: Model 17005A	$ 995
Options:	
001 Fan fold adapter	$ 125
002 Metric scale	N/C
004 Compatibility with 7004B-Option 004	N/C

Point plotting system
Model 7591A



7591A System

The 7591A is a fast and economical way to point plot analog data from computers, pulse height analyzers, signal averagers, and multi-channel analyzers. It plots on any size of sheet paper up to 11 x 17 in. or on roll or fanfold paper. The chart advance features include frame and incremental advance with a position accuracy of ±0.005 inch. Closed-loop plotting rates of up to 3000 plots/minute are attainable.

Specifications

Plot rate: Up to 50 plots/s. Limited by amplitude excursion of recorder.

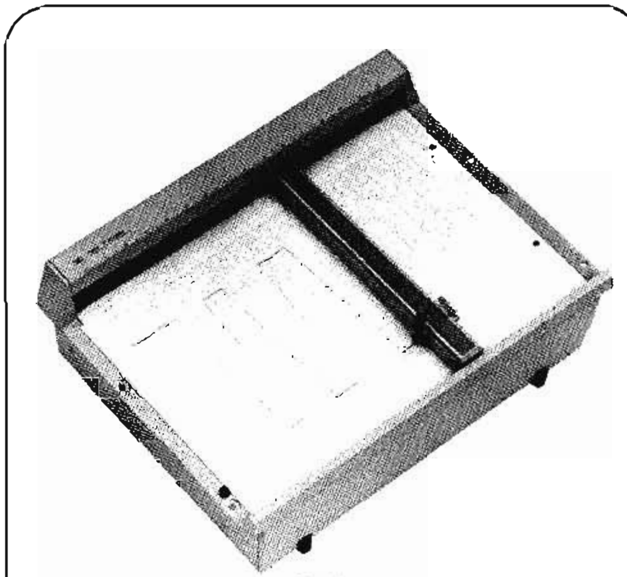
Price: Model 7591A (includes 7004B-004, 17173A, 17012B, and 17005A-004)—one additional plug-in is required for each axis.	$2810
Options:	
001 Metrically scaled and calibrated	N/C
002 X-axis retransmitting potentiometer, 5 kΩ, ±0.1% linearity	add $ 75
003 Fan fold adapter (used with 17005A)	add $ 125
008 7591A without 17005A (Option 004) Incremental Chart Advance	less $1045

SPECIAL PURPOSE
For OEM and dedicated applications
Models 7040A, 7041A

The 7040A and 7041A X-Y recorders are designed specifically for dedicated, single-purpose recording applications. The 7040A is a medium-speed unit for the majority of uses, while the 7041A is a high-speed unit featuring exceptionally fast acceleration for applications where recording time is critical or incoming data is at a high rate. Both units use the same rugged cast aluminum mainframe which forever eliminates the need for critical mechanical adjustments, the Autogrip holddown system which is silent and trouble-free with no moving parts, and a quick-change disposable pen.

Over 40 inexpensive options allow the recorder to be easily customized for nearly any specific task. Most can be easily and quickly installed or changed in the field should the recording requirement change. If some manual control is needed, a control panel (Option 038) may be added which provides the basic recorder functions such as zero set, servo, pen and chart handling. Other options include a time base, a plug-in X-axis event marker, TTL logic remote control and retransmitting potentiometers for both axes. The 7040 series option system avoids the cost and potential reliability problems associated with the extra, unused components when using a general-purpose recorder in a dedicated application.

A functional and quantity discount is available for both units when qualified for the OEM purchase agreement.



7040A

Specifications

Input ranges: single range from 0.5 mV/in. to 1 V/in. (0.2 to 500 mV/cm), specified by option choice.

Type of input: floating, 1 MΩ on all ranges, 200 V dc plus peak ac max; internal polarity switch; inputs through rear barrier strip or optional connector.

Common mode rejection: 100 dB dc; 80 dB at line frequency.

Slewing speed

7040A: 20 in./s (50 cm/s) min.

7041A: 30 in./s (75 cm/s) min.

Acceleration (peak)

7040A: Y axis 1000 in./s²; X axis 500 in./s².

7041A: Y axis 3000 in./s²; X axis 2000 in./s².

Accuracy: ±0.2% of full scale.

Sweep: optional, single range.

Zero set: external control provided by user; front panel controls available as Option 038.

Paper holddown: Autogrip electric paper holddown grips charts 11" x 17" and international A3 size or smaller.

Pen lift: electric pen lift controlled remotely by contact closure; TTL logic level provided by Option 039.

Dimensions: 14" high, 19" wide, 6½" deep (356 x 483 x 165 mm); rack mounting structure integral with unit.

Weight: net, 29 lbs (13,2 kg); shipping, 37 lbs (16,8 kg).

Power: 115 or 230 V ±10%, 50 to 400 Hz, approx 130 VA.

Prices

Model 7040A	$ 890
Model 7041A	$1050

Note: OEM discounts available on both models.

Optional Control Panel

Options

Input range (specify one range option for each axis; must be both English or both metric).

X	Y	Range	Price	X	Y	Range	Price
001	007	0.5 mV/in.	$ 30	013	019	0.2 mV/cm	$ 30
002	008	1 mV/in.	$ 30	014	020	0.5 mV/cm	$ 30
003	009	10 mV/in.	$ 30	015	021	5 mV/cm	$ 30
004	010	100 mV/in.	N/C	016	022	50 mV/cm	N/C
005	011	500 mV/in.	N/C	017	023	100 mV/cm	N/C
006	012	1 V/in.	N/C	018	024	500 mV/cm	N/C

Note: other ranges available on special order.

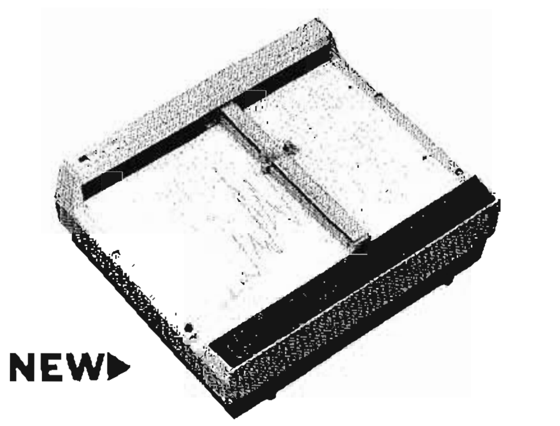
Sweep range (specified by option choice, X axis only; accuracy ±1% of full scale ±0.1%/°C max; TTL logic start and reset).

	Sweep	Price		Sweep	Price
025	1 s/in.	$125	030	0.5 s/cm	$125
026	5 s/in.	$125	031	1 s/cm	$125
027	10 s/in.	$125	032	5 s/cm	$125
028	50 s/in.	$125	033	10 s/cm	$125
029	100 s/in.	$125	034	50 s/cm	$125

Note: other sweep ranges available on special order.

035	Event marker, upper margin of X axis	$ 75
036	X axis retransmitting potentiometer (19.2 kΩ)	$ 50
037	Y axis retransmitting potentiometer (13.1 kΩ)	$ 50
038	Control panel; for line, pen lift, chart, servo standby, zero, and zero check; add 1¾" (44 mm) to height	$125
039	TTL logic remote control; for pen lift and servo standby; also event marker if installed	$ 50
040	Rear connector; X, Y input signals and retransmitting potentiometers, time base controls, Autogrip servo standby, pen lift, event marker and Option 039 control lines brought to a single locking connector	$ 75
041	Side trim panels and dust cover (14", for standard unit)	$ 15
042	Side trim panels and dust cover (15¾", for unit with Option 038 installed)	$ 15

GENERAL PURPOSE
High Performance
Model 7044A, 7045A



7045A

The 7044A and 7045A are general-purpose laboratory X-Y recorders, designed specifically to be the most reliable and versatile recorders in the field.

Both recorders are solid, functional, and dependable; both offer outstanding dynamic performance. The 7044A is a medium-speed recorder designed for most general-use applications. For difficult signal applications, the 7045A offers higher speed and Y-axis acceleration exceeding 3000 in./sec² (7620 cm/sec²). This high acceleration allows the 7045A to faithfully reproduce an extremely wide range of fast changing input signals.

Standard features include the AUTOGRIP paper holddown system which solidly grips any size paper up to 11 x 17 in., as well as the standard European size A3. There is also the disposable ink pen that produces a clean, crisp, continuous trace. Four easy to change colors are available to permit easy trace identification.

Performance specifications

Input ranges: 0.5, 1, 5, 10, 50 mV/in.; 0.1, 0.5, 1, 5, 10 V/in. (metric calibration available in 0.25, 0.5, 2.5, 5, 25 mV/cm; 0.05, 0.25, 0.5, 2.5, 5 V/cm). Continuous vernier between ranges.

Type of input: floating, 500 V dc or peak ac maximum. Polarity reversal switch located on front panel, guard internally connected. Inputs through front panel 5-way binding posts or optional rear connector.

Input resistance: 1 megohm constant on all ranges.

Common mode: 110 dB dc and 90 dB at 50 Hz and above (exceeds 130 dB dc and 110 dB ac under normal lab environmental conditions) with 1 k ohm between HI and LO terminals, CMR voltage applied between ground and LO, and attenuator on most sensitive range. CMR decreases 20 dB per decade step in attenuation.

Slewing speed:
7044A—20 in./sec (50 cm/sec) minimum.
7045A—Fast Response, 30 in./sec (76 cm/sec) minimum. Slow Response, 15 in./sec (36 cm/sec) typical.

Acceleration (peak):
7044A—Y-axis 1000 in./sec² (2540 cm/sec²), X-axis 500 in./sec² (1270 cm/sec²).
7045A—(Fast Response only) Y-axis 3000 in./sec² (7620 cm/sec²). X-axis 2000 in./sec² (5080 cm/sec²).

Accuracy: ±0.2% of full scale (±0.01%/°C).

Linearity (terminal based): ±0.1% of full scale.

Resettability: 0.1% of full scale.

Overshoot: 7044A—2% of full scale (maximum). 7045A—1% of full scale (maximum).

Zero set: zero may be placed anywhere on the writing area or electrically off scale up to one full scale from zero index.

Environmental (operating): 0° to 55°C and <95% relative humidity (40°C).

General specifications

Writing mechanism: servo actuated ink pen.

Writing area: 10" x 15" (25 cm x 38 cm).

Paper holddown: Autogrip electric paper holddown grips chart 11" x 16.5" and European size A3 (29,7 cm x 42 cm) or smaller. Special paper not required.

Pen lift: electric (remote, Option 007, via contact closure or TTL level).

Dimensions: 15¾" high, 19" wide, 6½" deep (400 x 483 x 165 mm); rack mounting structure integral with unit.

Power: 115 or 230 V ac ±10%, 50 to 400 Hz; 7044A, 135 VA; 7045A, 175 VA.

Weight: net, 30 lb (13,7 kg); shipping, 42 lb (19,1 kg).

Prices: 7044A, $1350; 7045A, $1675.

Options

Opt 006: Metric Calibration, N/C.

Opt 001: Time Base, add $200.
- **Sweep rates:** 0.5, 1, 5, 10, 50, 100 sec/in. (metric calibration is 0.25, 0.5, 2.5, 5, 25, 50 sec/cm).
- **Accuracy:** ±1% of full scale at 25°C (±0.1%/°C maximum).
- **Linearity** (terminal based): ±0.5% of full scale at 25°C (±0.04%/°C maximum).

General: switchable to either X or Y axis. Start and reset by front panel control, remote (requires rear connector option) by momentary contact closure to ground or TTL levels. Automatic reset at full scale, recycle accomplished by continuous start signal.

Opt 002: Event Marker[1], add $75. Writes in upper margin, aligned with X-axis position, approximately 0.05 in. (0.13 cm) excursion completed 50 msec after application of signal. Controlled remotely by contact closure to ground or by TTL levels (Opt 005).

Opt 003: Retransmitting Potentiometers (X-axis)[1], add $50.

Opt 004: Retransmitting Potentiometers (Y-axis)[1], add $50.
- **Resistance:** 19.2 k ohm ±10% (X-axis), 13.1 k ohm ±10% (Y-axis).
- **Linearity** (terminal based): ±0.1% of full scale.
- **Contact resistance:** 4 k ohm (maximum).

Opt 005: TTL Level Remote Control[1], add $50. Allows TTL level remote control (contact closure (0.2 mA) to ground or TTL levels) of Autogrip, servo standby, and (7045A only) X and Y response mode.

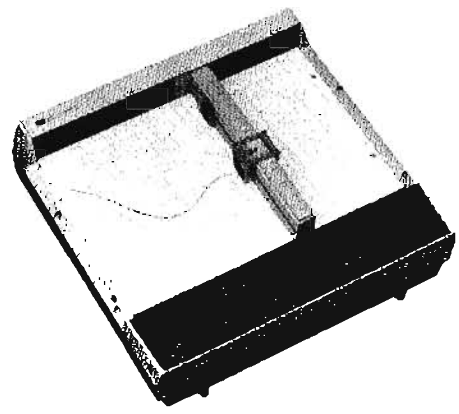
Opt 007: Rear Connector, $50. Connects X and Y input signals, pen lift, event marker, X and Y retransmitting potentiometers, time base and TTL controls.

[1] Requires rear connector option.

TWO PEN $X\text{-}Y_1, Y_2$
Simultaneous Plotting of Three Parameters
Model 7046A

The 7046A is a general purpose 2-pen laboratory X-Y recorder, designed to assure high quality recordings and yet to maintain the ruggedness, reliability, and high performance required of a laboratory recorder. This solid, functional, and dependable general purpose unit offers dynamic performance that surpasses all other 2-pen recorders by offering Y-axis acceleration exceeding 2500 in./sec² (6350 cm/s²). This high acceleration plus virtually no overshoot allows the 7046A to faithfully reproduce an extremely wide range of fast-changing input signals.

Standard features include the AUTOGRIP paper hold-down system which solidly grips any size paper up to 11 x 17 in., as well as the standard European size A3. The new thin line disposable pens feature a visible ink supply and permit a trace separation of 0.05 in. (1.2 mm). These pens—available in three colors—produce clean, crisp, continuous traces.



NEW 7046A

Performance specifications

Input ranges: 0.5, 1, 5, 10, 50 mV/in.; 0.1, 0.5, 1, 5, 10 V/in. (metric calibration available in 0.25, 0.5, 2.5, 5, 25 mV/cm; 0.05, 0.25, 0.5, 2.5, 5 V/cm). Continuous vernier between ranges.

Type of input: floating, 500 V dc or peak ac maximum. Polarity reversal switch located on front panel, guard internally connected. Inputs through front panel binding posts or optional rear connector.

Input resistance: 1 megohm constant on all ranges.

Common mode: 110 dB dc and 90 dB at 50 Hz and above exceeds 130 dB dc and 110 dB ac under normal lab environmental conditions) with 1 k ohm between HI and LO terminals, CMR voltage applied between ground and LO, and attenuator on most sensitive range. On other ranges, CMR decreases 20 dB per decade step in attenuation.

Slewing speed: Fast Response, 30 in./s (76 cm/s) minimum; Slow Response, 15 in./s (36 cm/s) typical.

Acceleration (peak, fast response only):
Y-axes 2500 in./s² (6350 cm/s²), X-axis 1500 in./s² (3800 cm/s²).

Accuracy: ±0.2% of full scale (±0.01%/°C).

Linearity (terminal based): ±0.1% of full scale.

Resettability: 0.1% of full scale.

Overshoot: 1% of full scale (maximum).

Zero set: zero may be placed anywhere on the writing area or electrically off scale up to one full scale from zero index.

Environmental (operating): 0 to 55°C and <95% relative humidity (40°C).

General specifications

Writing mechanism: servo actuated ink pens, offset by 0.05 in. (0,12 cm) in X direction.

Writing area: 10″ x 15″ (25 cm x 38 cm).

Paper holddown: Autogrip electric holddown grips charts 11″ x 16.5″ and standard European DIN A3 (29,7 cm x 42 cm) or smaller. Special paper not required.

Pen lift: electric (remote, Option 008, via contact closure or TTL level).

Dimensions: 17⅜″ high, 19″ wide, 6-13/16″ deep (441 x 483 x 173 mm); rack mounting structure integral with unit.

Power: 115 or 230 volts ac ±10%, 50 to 400 Hz, 175 VA.

Weight: net, 35 lb (16 kg); shipping, 47 lb (21,4 kg).

Price: Model 7046A, $2650.

Options

Opt 007: Metric Calibration, N/C.

Opt 001: Time Base, $200.
- **Sweep rates:** 0.5, 1, 5, 10, 50, 100 s/in. (metric calibration is 0.25, 0.5, 2.5, 5, 25, 50 s/cm).
- **Accuracy:** ±1% of full scale at 25°C (±0.1%/°C maximum).
- **Linearity** (terminal based): ±0.5% of full scale at 25°C (±0.04%/°C maximum).
- **General:** switchable to X-axis. Start and reset by front panel control, remote (requires rear connector option) by momentary contact closure to ground or TTL levels. Automatic reset at full scale, recycle accomplished by continuous start signal.

Opt 002: Event Marker[1], $75. Writes in upper margin, aligned with X-axis position of Y pen, approximately 0.05 in. (0,12 cm) excursion completed 50 ms after application of signal. Controlled remotely by contact closure to ground or by TTL levels.

Opt 003: Retransmitting Potentiometers[1], X axis, $50.

Opt 004: Y_1 axis, $50.

Opt 005: Y_2 axis, $50.
- **Resistance:** 19.2 k ohms ±10% (X-axis); 13.1 k ohms ±10% (Y-axis).
- **Linearity** (terminal based): ±0.1% of full scale.
- **Contact resistance:** 4 k ohms (maximum).

Opt 006: TTL Level Remote Control[1], $75. Allows TTL level remote control (contact closure (0.2 mA) to ground or TTL levels) of Autogrip, servo standby, and X, Y_1, Y_2 response mode.

Opt 008: Rear Connector, $75. Connects input signals, pen lift, event marker, retransmitting potentiometers, time base, and TTL controls.

[1]Requires rear connector option.

TWO PEN & HIGH GAIN X-Y RECORDERS
Record Y_1, Y_2 f(x); high gain with high CMR
Model 136A; Model 7001A

Two Pen X-Y_1, Y_2—Model 136A

136A

The 136A is a two-pen X-Y_1, Y_2 graphic recorder available with English or metric scaling for bench or rack mounting. Features include a built-in time base on the X axis with 5 calibrated sweeps, 11 input voltage ranges with a continuous vernier that scales input voltages to fit the paper, a full-scale zero set and suppression, and local and remote pen lift. Two-pen capability makes these recorders extremely useful for plotting 3 parameters simultaneously. The two pens traverse the full X axis with no more than 0.1 inch horizontal separation.

Specifications

Input ranges: 0.5, 1, 5, 10, 50 mV/in.; 0.1, 0.5, 1, 5, 10, 50 V/in.; metric models: 0.2, 0.5, 2, 5, 20, 50 mV/cm; 0.2, 0.5, 2, 5, 20 V/cm. Variable range mode all positions.

Input resistance: one megohm at null on all fixed ranges. Variable range mode, 100,000 ohms on four most sensitive ranges and one megohm on all others. Potentiometric input is available on the four most sensitive ranges of the X axis by removal of an internal strap and on both Y axes by a front panel switch.

Maximum allowable source impedance: up to 10 kΩ source impedance will not alter recorder's performance on the four lowest ranges. No source impedance restrictions on above 10 mV/in.

Time sweeps: (on X axis only) 0.5, 1, 5, 10, 50 s/in.; metric: 0.2, 0.5, 2, 5, 20 s/cm. Accuracy, 5% of full scale.

Accuracy: 0.2% of full scale.

Linearity: 0.1% of full scale.

Resettability: 0.1% of full scale on all ranges.

Reference stability: better than 0.002%/°C.

Slewing speed: 60 Hz operation: 20 in./s (50 cm/s) on the X-axis; 15 in./s (38 cm/s) on Y_1 and Y_2 axes max.
50 Hz operation: 16 in./s (40 cm/s) on the X axis; 12 in./s (30 cm/s) on the Y_1 and Y_2 axes max.

Paper holddown: Autogrip paper holddown electrostatically grips charts of any size up to size of platen.

Pen lift: local and remote.

Power: 115 or 230 V, 50 or 60 Hz, 130 VA.

Dimensions: 14" high, 17⅞" wide, 6-3/16" deep (355 x 454 x 157 mm).

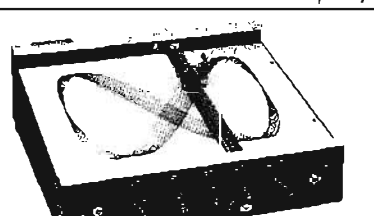
Weight: net, 34 lb (15,45 kg); shipping, 47 lb (21,3 kg).

Price: 136A (English), 136AM (metric), $2850.

Options:

002	Rear input connectors (supplied with mating connectors)	add $ 15
003	5 kΩ retransmitting potentiometer—X axis	add $100
004	Disposable pen tips	N/C

100μ V/Inch Sensitivity—Model 7001A



7001A Series

The 7001A X-Y recorder has high sensitivity, high common mode rejection and specially guarded and shielded input circuitry. Units are available for bench (7001A) or rack mounting (7001AR), and with metric or English scaling.

Sweep features include automatic reset, adjustable sweep length and automatic recycling. The time base may be switched to operate on either axis. Zero offset for each axis may be preset in 5-inch calibrated steps up to 4 scale lengths on the Y axis and 3 scale lengths on X with continuous adjustability between steps. Zero check pushbutton switches are provided on each axis. Input impedance is 1 MΩ at null on all ranges, with potentiometric input possible on the 6 most sensitive ranges by internal strap or optional front panel switch.

Specifications

Input ranges: 19 ranges, 0.1 mV/in. to 20 V/in. in a 1, 2, 5 sequence (0.05 mV/cm to 10 V/cm in a 1, 2.5, 5 sequence). Continuous vernier between ranges.

Type of input: floating and guarded signal pair.

Maximum allowable source impedance: 10 kΩ on first 6 ranges; no restrictions on ranges above 5 mV/in.

Interference rejection: dc CMR 140 dB on first 3 ranges; 120 dB at power line frequency on first 2 ranges.

Time sweeps: 0.5, 1, 2, 5, 10, 20, 50, 100 s/in. (0.25, 0.5, 1, 2.5, 5, 10, 25, 50 s/cm). Accuracy ±2%.

Accuracy: ±0.2% full scale.

Reference stability: better than 0.005%/°C.

Slewing speed: 20 in./s each axis at 60 Hz; 16 in./s at 50 Hz.

Paper holddown: Autogrip paper holddown electrostatically grips charts of any size up to size of platen.

Pen lift: local and remote.

Power: 115/230 V, 50 to 60 Hz, approximately 120 VA.

Dimensions: bench: 6½" high, 17½" wide, 17" deep (164 x 445 x 432 mm); rack: 17-7/16" high x 19" x 5⅜" (443 x 483 x 136 mm).

Weight: net, 35 lbs (15,9 kg); shipping, 46 lbs (20,9 kg).

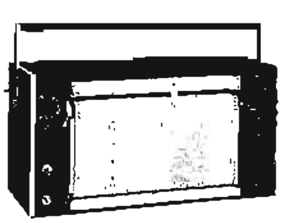
Price: 7001A/AR (English), 7001AM/AMR (metric), $2275.

Options:

001	Potentiometric switch (first 6 ranges)	$ 55
004	X axis retransmitting potentiometer (5 kΩ)	$ 75
005	Rear input terminals	$ 50
006	Y axis retransmitting potentiometer (5 kΩ)	$ 75
007	Retransmitting potentiometers on both axes	$150
009	Event marker (X axis)	$100
010	Disposable pen tips	N/C

Much of the instrumentation which extends, refines or supplements human perception produces information in the form of electrical analog signals. Records of such data are, of course, necessary. Electrical data acquired in serial fashion, comprising a chain of meaningful changes in a signal, record naturally on continuous instruments such as strip chart recorders. The character of the signal will determine the appropriate recording instrument. Permanent records of slowly changing analog values are conveniently made by Hewlett-Packard servo-driven strip chart recorders; oscillographic recorders (see page 225) can handle signals from dc to 150 Hz.

Parallel-input digital data may also be directly recorded using the Model 580A or 581A Digital to Analog Converter. Outputs from most Hewlett-Packard counters, digital voltmeters and other digital measuring devices are converted to analog signals for recording on any strip chart recorder.



7100B

Strip chart recorders

Laboratory and industrial recorders are available that produce records in rectilinear coordinates with considerable accuracy—typically 0.2%. Two-pen models permit both channels to realize the full resolution of the chart width simultaneously, since the pens can overlap on the same chart without interference.

Selection of a servo-driven strip chart recorder depends upon the specific application. Highest sensitivity is offered by the 7100 series plug-in recorders (7100B, 7101B, 7127A, 7128A) with choices to 100 μV full scale. Another plug-in measures temperature directly from a thermocouple input. The 7100B and 7101B offer 12 chart speeds, the 5" Model 680 eight speeds and the 7127A and 7128A four speeds.

For OEM or other dedicated applications, the 7123 and 7143 offer the utmost reliability at lowest cost. Both utilize a linear motor servo system with only one moving part, achieving reliability through simplicity. Many options are available to customize the recorder for a particular task. OEM discounts are available on all Hewlett-Packard servo-driven strip chart recorders.

Options are available on all units to match a particular application. Some of the most popular are:

Event markers—to register external events in time relationship to the chart recording.

Retransmitting potentiometers — additional slidewires which provide an electrical output proportional to the pen position for controlling external devices.

Limit switches—to provide control or alarm signals when the recorder pen reaches a pre-set limit.

Chart integrator—a second recording on the same chart which counts the integral of the main signal.

Basic operation

Each Hewlett-Packard servo-driven strip chart recorder uses an individual electrical servo system for each channel employed. All servos are similar. Each consists of a basic balancing circuit, plus auxiliary elements for instrument versatility.

A basic potentiometric servo recorder, illustrated in the block diagram, shows a single range recorder in its simplest form. V_{in} is the input signal voltage to the recorder and is applied to the input of the amplifier causing the motor to be driven. The motor rotates, causing an electrical tap at V_b to be adjusted to a point where V_b equals V_{in}. At this point, the input voltage to the amplifier is zero, and the motor stops. This is considered a balanced condition and the degree of balance attained is largely a function of the amplifier's gain. If the input voltage (V_{in}) changes, the balancing action is repeated.

Controls and circuits used to provide versatility are:

1. Stepped attenuators for each axis so that input voltages from the microvolt range to 500 volts can be handled directly.
2. Variable attenuators provide continuous adjustment to allow a transducer's output to correspond directly to the paper's coordinates in the desired units of measurement (psi, °C, etc.).
3. Zero controls allow the plotting origin to be placed anywhere on the paper or suppressed electrically off the paper.

Types of writing systems

Hewlett-Packard strip chart recorders provide three types of writing systems: ink, electric and thermal writing. Thermal and ink writing are used on Hewlett-Packard oscillographic recorders.

Electric writing as well as ink is available on all Hewlett-Packard servo-driven strip chart recorders. With the elimination of ink refilling, long term unattended recording with maximum reliability is possible. Hewlett-Packard low voltage electric writing features crisp, clean, permanent records with the advantage of instant start-up. The record is not sensitive to light or pressure, thus eliminating special handling; it is permanent without processing.

Hewlett-Packard servo-driven strip chart recorders

Description	Model	Chart Width (in.)	Page	Maximum Span (mV)	Chart Speeds	Other	Price
General Purpose (One-Channel)	680	5	223	5	8		$ 900
	7101B	10	218	0.1[1]	12	Plug-ins	1000[1]
	7127A	10	218	0.1[1]	4	Plug-ins	850[1]
General Purpose (Two-Channel)	7100B	10	218	0.1[1]	12	Plug-ins	1500[1]
	7128A	10	218	0.1[1]	4	Plug-ins	1350[1]
OEM	7130A	10	222	1	1[2]		1250
	7123A	10	220	1	1[2]		750
	7143A	5	220	1	1[2]		695

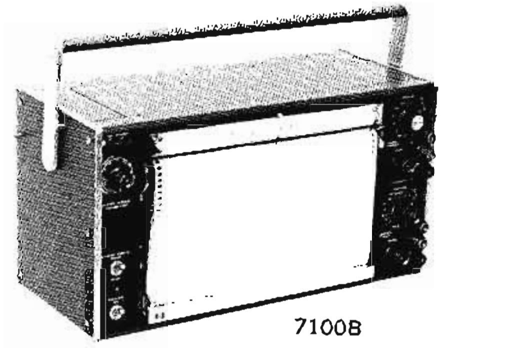
[1]Depends on Plug-in Selection.

[2]Two and four speed options available.

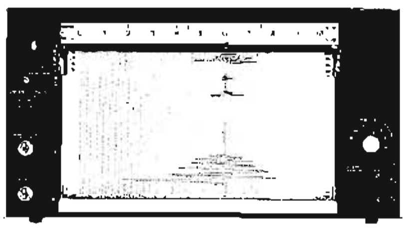
10 in. PLUG-IN RECORDERS

Ink and electric writing

Models 7100B, 7101B, 7127A, 7128A



7100B



7127A

Ten-inch strip chart recorders are widely used in laboratory and industrial applications. Hewlett-Packard strip chart recorders feature high performance, low cost, and solid-state construction for reliability, compactness, and light weight. Models 7100B and 7128A have two servo pen drives and require two input modules. The 7101B and 7127A are single pen units and take one input module. Ordering information should specify basic frame and exact input modules required.

Each main frame is equipped with selectable chart speeds (4 for 7127A, 7128A; 12 for 7100B, 7101B) and a modular chart magazine. The chart magazine will swing out to a 10° or 30° angle for convenient note writing. An optional integrator that computes the area under the chart curve is available.

Specifications

Performance specifications

Recording mechanism

Ink: servo actuated ink pen drive.

Electric: a stylus with associated electronics and electro-sensitive paper are furnished.

Chart dimensions: (ink writing) 120′ chart rolls, 11″ wide with 10″ (250 mm) calibrated writing width. (Electric writing) 100′ chart rolls, 11″ wide with 10″ (250 mm) calibrated writing width.

Chart speeds: 7100B/7101B (English): 1, 2 in./hr; 0.1, 0.2, 0.5, 1, 2 in./min; 0.1, 0.2, 0.5, 1, 2 in./s. 7100BM/7101BM (Metric): 2.5, 5, 15, 30 cm/hr; 1.25, 2.5, 5, 15, 30 cm/min; 1.25, 2.5, 5 cm/s. 7127A/7128A (English): ¼, ½, 1, 2 in./min.

Linearity: terminal based, 0.1% of full scale.

Resettability: 0.1% of full scale.

(Other specifications listed under plug-in modules.)

General specifications

Power: 115 or 230 V ±10%, 60 Hz, 65 VA for 7100B and 7128A; 42 VA for Models 7101B and 7127A. 115 or 230 V, 50 Hz models available as option.

Dimensions: 7100B/7101B series (cabinet): 11-31/32″ high, 17½″ wide, 8¼″ deep (304 x 445 x 210 mm). 7100BR/7101BR (rack): 8-23/32″ high, 19″ wide, 8¼″ deep (222 x 483 x 210 mm). 7127A/7128A series (cabinet): 9-3/32″ high, 16¾″ wide, 8¼″ deep (231 x 425 x 210 mm). (rack; brackets supplied) 8-23/32″ high, 19″ wide, 8¼″ deep (222 x 483 x 210 mm).

Weight: 7100B series: net, 28 lb (12,7 kg); shipping, 39 lb (17,7 kg). 7101B series: net, 28 lb (12,7 kg); shipping, 33 lb (17,3 kg). 7127A series: net, 25 lb (11,4 kg); shipping, 35 lb (15,9 kg). 7128A series: net, 28 lb (12,7 kg); shipping, 38 lb (17,3 kg).

Prices

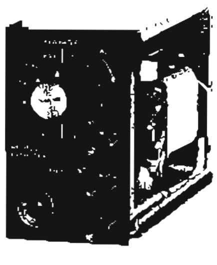
Dual channel: 7100BR (English), 7100BM/BMR (metric) $1500; 7128A (English only) $1350.

Single channel: 7101B/BR (English), 7101 BM/BMR (metric) $1000; 7127A (English only) $850.

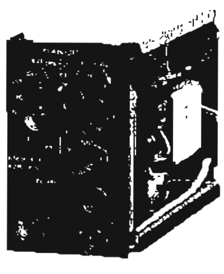
Options

7100B 7101B	7127A 7128A	Description	Additional price 7100B 7101B	Additional price 7127A 7128A
004	014	5kΩ retransmitting potentiometer (channel 1)	50	$50
005	001	High-low limit switches (channel 1)	50	50
006	008	Remote control of electric pen lift	50	50
007	002	Remote on-off chart control	25	25
010	003	50 Hz operation	N/C	N/C
011	013	Locking glass door	50	50
012	004	Event marker (ink) left side	35	35
014	006	Event marker (ink) both sides	70	70
015	007	Integrator (7127A, 7101B series or channel 2 of 7128A, 7100B series)	795	795
016	015	5kΩ retransmitting potentiometer (channel 2)	50	50
017	009	High-low limit switches (channel 2)	50	50
018	010	High-low limit switches (both channels)	100	100
019	017	Electric writing	75	75
020	020	Scale with "0" right side	N/C	N/C
022	022	Event marker (elec) left side	35	35
023	023	Event markers (elec) both sides	70	70
024	024	Disposable pen tips (servo pens only)	N/C	N/C
025	025	Soft zero right side	N/C	N/C
–	026	GC compatibility	–	N/C
–	011	Carrying handle	supplied	25
–	016	Retransmitting potentiometer (both channels)	–	100
–	H01	6, 12, 24, 48 in./hr.	–	N/C
–	H02	1½, 3, 6, 12 in./hr.	–	N/C

Note: 7100B, 7101B: Option 015 is not compatible with options 014, 016, 019, 022, or 023. Options 015, 019, and 025 require special paper. 7127A, 7128A: Options 006, 015, 016, 017, 022, or 023 cannot be installed when instrument is equipped with Option 007. Options 007, 017, and 025 require special paper. Electric and ink writing systems are not compatible. Event markers must be of same type as the main writing system.



5 mV to 100 V
17500A



1 mV to 100 V
17501A

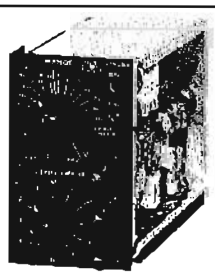
Multiple Input Span Modules

The Models 17500A (5 mV full scale) and 17501A (1 mV full scale) Multiple Span plug-ins offer high input resistance and a continuously variable span control. Common mode rejection is high and input impedance is one megohm at null on all calibrated spans.

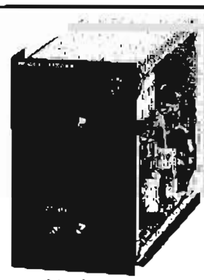
Temperature
17502A

Temperature Modules

The Model 17502A Temperature Measuring Input Module has a single span selectable to match almost any commonly used thermocouple. Corrections for changes in ambient temperature are made within the module, eliminating need for a remote compensation junction. Non-linear thermocouple output is converted in the module to a linear function of temperature permitting use of standard ruled graph paper.



100 μV to 100 V
17505A



Choice of Spans
17506A

High Sensitivity Modules

The 17505A High Sensitivity Input Module expands the sensitivity capability to 100 μV full scale. Maximum sensitivity allows input signal variations smaller than 1 μV to produce accurate measurable recordings. The 17506A plug-in may be ordered with any single span from 100 μV to 100 V full scale. Both feature floating inputs up to 500 V dc.

17500A/17501A Specifications

Voltage spans: 17500A: 5, 10, 50, 100, 500 mV; 1, 5, 10, 50, 100 V full scale. 17501A: 1, 2, 5, 10, 20, 50, 100, 200 mV; 0.5, 1, 2, 5, 10, 20, 50, 100 V full scale.
Accuracy: ±0.2% of full scale.
Input resistance: 1 megohm at null on all fixed calibrated and variable spans except 100 kΩ in the variable mode on the four most sensitive spans on the 17500A only. Potentiometric operation is available on the 17500A on the four most sensitive spans and to the 17501A on the six most sensitive spans.
Interference rejection: dc common mode; 120 dB on the four most sensitive spans of the 17500A and the three most sensitive of the 17501A. Line frequency, 100 dB on the four most sensitive spans of 17500A and the three most sensitive of 17501A.
Zero-set: adj. full scale, plus one full scale of suppression. 5 scales of zero suppression available on the 17501A.
Maximum source impedance: up to 10 kΩ source impedance will not alter the recorder's performance on the four most sensitive spans of the 17500A and the six most sensitive of the 17501A. No source impedance restrictions on spans above 100 mV fs.
Reference stability: 0.005%/°C.
Weight: net, 2 lb (0,9 kg); shipping, 5 lb (2,2 kg).
Prices

Model 17500A	$ 325	Model 17501A	$ 375

Options

001	five-scale zero suppression (17501A only)	$ 50
002	calibrated for use with integrator (8" span)	N/C

17502A Specifications

Voltage spans: single span to match cold-junction thermocouples of types J, K, R, S, and T at ranges as listed on the data sheet.
Accuracy: ±0.5% or ±1°C, (whichever is greater); refer to NBS CIR 561, dated 1955.
Input resistance: potentiometric.
Interference rejection: dc common mode, 120 dB; line frequency, 100 dB.
Weight: net, 4 lb (1,8 kg); shipping, 7 lb (3,2 kg).
Price: Model 17502A $ 400

17505A/17506A Specifications

Voltage spans: 17505A: .1, .2, .5, 1, 2, 5, 10, 20, 50, 100, 200, 500 mV; 1, 2, 5, 10, 20, 50, 100 V full scale. 17506A: any one of the above spans (specify).
Accuracy: ±0.25% of full scale.
Input resistance: 1 MΩ at null.
Interference rejection: dc CMR: 120 dB on most sensitive span. Line frequency CMR: 100 dB on most sensitive span. Line frequency normal mode: 17505A: switchable, 60 dB or 100 dB. 17506A: 100 dB.
Zero set: +2, −1.5 scales. Optional calibrated offset of +1 to −10 scales in one scale steps on 17505A.
Zero stability: ±1 μV after one hour.
Maximum source impedance: 10 kΩ on nine most sensitive spans; no source impedance restrictions on spans above 100 mV fs.
Reference stability: 0.005%/°C.
Weight: net, 2 lbs (0,9 kg); shipping, 5 lbs (2,2 kg)
Price

Model 17505A	$400
Model 17506A (specify voltage span)	$250
Additional range cards for 17506A	$ 25

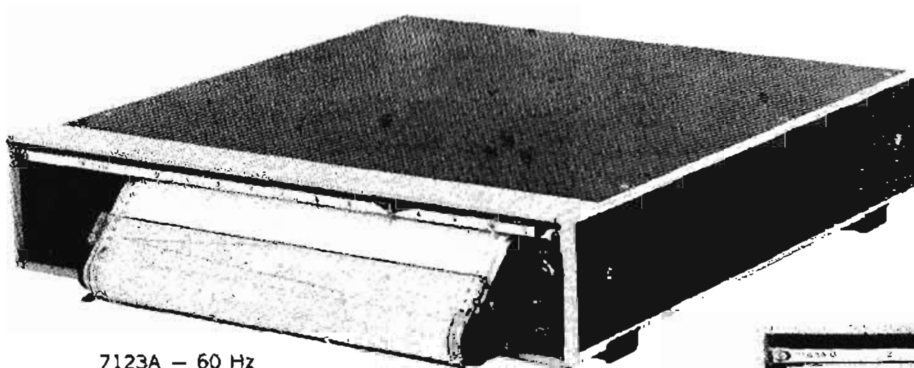
Options

001	Calibrated offset: +1 to −10 scales in one scale steps. Accuracy ±0.25% per step. (17505A only.)	$100
002	Calibrated for integrator use (8" span)	N/C
003	50 Hz operation	N/C

10 in. AND 5 in. RECORDERS

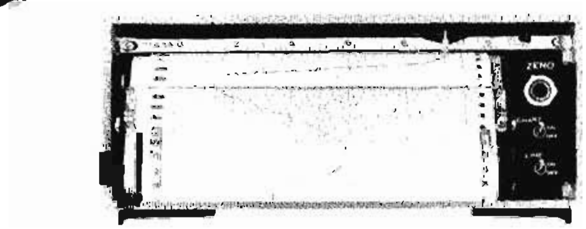
Linear motor drive—dedicated applications

Models 7123A/B and 7143A/B



7123A — 60 Hz
7123B — 50 Hz

7143A — 60 Hz
7143B — 50 Hz



The 7123A/B and 7143A/B Strip Chart Recorders were developed specifically for dedicated recording applications. High reliability and exceptional performance plus a multitude of options allow custom tailoring to each application. These 3½ inch high recorders conserve rack space but still incorporate an effective chart drive and chart viewing system.

The 7123A/B uses chart paper with a 10 inch wide grid, the 7143A/B accommodates paper with a 5 inch grid. The suffix A denotes a recorder for use at 60 Hz line frequency; B denotes 50 Hz.

Reliability

Reliability is the keynote. Maximum reliability was achieved through the development of a unique linear servo motor. The motor enabled the design of a servo drive system with only one moving part—the motor slider/pen assembly. This single moving part replaces the many cables, pulleys, and gears found in a conventional servo system.

The entire radial field of the motor is produced by a permanent magnet, resulting in low power consumption and virtually no internal temperature rise. In addition, the motor can be driven continuously off scale with no audible noise and no possibility of damage to the recorder.

The traditional weak link of servo recorders has been eliminated. A conductive film potentiometer is used in place of the conventional wirewound slidewire. This conductive film potentiometer results in an order of magnitude increase in feed-back element life.

Electric writing

Electric writing (Option 036) is available to further enhance reliability and convenience. Using electrosensitive paper, the low voltage electric writing system provides a crisp, clear trace, eliminating the need for ink refilling and pen priming. The recorded trace is permanent, chemically stable, and insensitive to pressure and moisture. Totally unattended operation is acheivable.

Precise response

The linear motor also provides extremely quick response, producing full scale response in less than ¼ second (1/3 second for 7123A/B). In addition, non-mechanical tachometer feedback is incorporated. The tachometer and the high gain solid state servo amplifier allow the units to faithfully reproduce the input signal and respond to step inputs with less than 1% overshoot.

Versatile chart drive

A unique chart drive and viewing system is incorporated. The system allows the paper to be rolled up, or to be fed out and conveniently torn off for inspection or filing. In addition, a slanted viewing/writing area is incorporated to facilitate both viewing and note making. Chart paper may be manually advanced at any time without gear changing or performance interruption.

Minimum panel height

The unique linear motor and chart drive/viewing system combine to make a recorder that requires only 3½ inches of rack height. This low silhouette provides the user with additional rack space without sacrificing recorder capability.

Low cost

The basic price is low. Additional savings are available when qualified for the OEM Purchase Agreement.

Flexibility with options

With almost 50 options available, the 7123A/B and 7143A/B can be "designed" to fit your exact requirements. Most options are modular and options such as span and chart speed can be changed in the field if the need arises.

Performance specifications

Input ranges: single span, 1 mV thru 100 V (specified by option).
Type of input: single ended, floating.
Input resistance: 1 MΩ constant on all spans.
Maximum allowable source resistance (R_s): 10 kΩ.
Normal mode rejection (at line frequency): >6 dB.
Common mode rejection: >100 dB at dc and >80 dB at line frequency.
Response time: 7143A/B: <⅓ s (<½ s for spans below 1 V). 7123A/B: <⅓ s (<½ s for spans below 1 V).
Overshoot: <1% of full scale.
Accuracy (including linearity and deadband): 7123A/B: ±0.25% of full scale. 7143A/B: ±0.5% of full scale.
Zero drift: <±0.2 μV/°C ±0.007% of full scale/°C.
Linearity (terminal based): ±0.1% full scale.
Reference stability: ±0.002%/°C.
Chart speeds: speed determined by option choice.
Chart speed accuracy: synchronous with line frequency.
Zero set: left hand, adjustable ±1 full scale (right hand optional).
Environmental (operating): 0°C to 55°C, <95% relative humidity (25° to 40°C).

General specifications

Writing mechanism: servo actuated ink pen (electric writing optional).
Grid width: 7123A/B 10" or 25 cm. 7143A/B 5" or 12 cm.
Chart length: 95 ft or 28,5 meters (electric option 55 ft or 16.5 meters).
Pen lift: manual (electric optional).
Power: 7123A/7143A: 115/230 V ±10%, 60 Hz, 45 VA. 7123B/7143B: 115/230 V ±10%, 50 Hz, 45 VA.
Dimensions: 7123A/B: 3½" high, 17" wide, 19¼" deep (89 x 432 x 489 mm). 7143A/B: 3½" high, 8½" wide, 19¼" deep (89 x 216 x 489 mm).
Weight: 7123A/B: net, 42 lb (19 kg); shipping, 51 lb (23 kg). 7143A/B: net, 25 lb (11.3 kg); shipping, 33 lb (15 kg).
Price: 7123A/B: $750. 7143A/B: $695.

Note: OEM discounts available.

Options

Span (specify one, front scale determined by choice of English or metric chart speed).

Span	Option	Price	Span	Option	Price
1 mV (1.2)*	001	$150.	1 V (1.2)*	008	N/C
5 mV (6)*	002	$150.	5 V (6)*	009	N/C
10 mV (12)*	003	$100.	10 V (12)*	010	N/C
50 mV (60)*	004	$100.	50 V (60)*	011	N/C
100 mV (120)*	005	$100.	100 V (120)*	012	N/C
500 mV (600)*	006	$100.			

*Metric 7143A/B
Note: additional spans are available on special order.

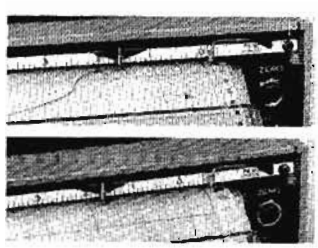
Speed	Option	Price		Option	Price
6 in./min	016	N/C	15 cm/min	022	N/C
4 in./min	017	N/C	10 cm/min	023	N/C
1 in./min	018	N/C	5 cm/min	024	N/C
½ in./min	019	N/C	3 cm/min	025	N/C
¼ in./min	020	N/C	15 cm/hr	026	N/C
1 in./hr.	021	N/C	3 cm/hr	027	N/C
2, 1, ½, ¼ in./min				045**	$155
5, 2.5, 1, 0.5 cm/min				048**	$155

Note: additional speeds are available on special order

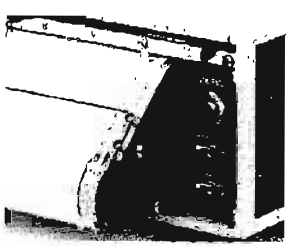
Chart speed control

Description	Option	Price
60:1 speed reducer	028	$20.
10:1 speed reducer	029	$20.
4:1 speed reducer	030	$20.
2:1 speed reducer	044	$20.
Remote speed change*	031**	$25.
Remote chart ON-OFF*	032**	$25.
Remote pen lift*	033**	$20.
Filter (adds 60 dB normal mode rejection)		
For spans 1 mV thru 5 mV,	007	$45.
For spans 10 mV thru 100 V,	013	$30.
Electronic chart integrator	035**	$750.
Electric writing	036**	$35.
Event marker (RH)*		
Ink	034**	$40
Electric	037**	$35.
Right hand zero		
Hard (scale, 10 to 0)	014	N/C
Soft (scale, 10 to −0.5)	015	N/C
Retransmitting pot		
4 kΩ ±3% linearity (10 V dc max)	039	$50.
Limit switch (front panel adjustable)		
SPDT contacts (2A@ 30 Vdc resistive).	040**	$120.
TTL Level	046**	$120.
Rack slides (7123A/B only)	043	$65.
Option power supply (required for options 031, 032, 033, 034, 035, 036, 037, 040, 045, 046, 048)	041	$40.

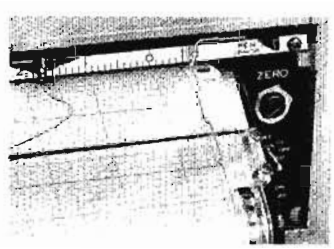
* Actuated by contact closure to ground. Closed circuit current 1.5 mA (max), open circuit voltage +1.5 V (max).
** Requires Option Power Supply (Option 041).



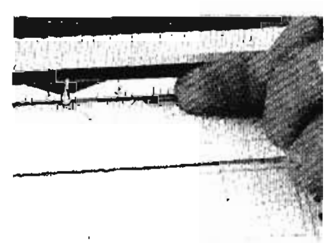
014 RH Hard Zero
015 RH Soft Zero



028, 029, 030, 044
Speed Control



034 Ink
037 Electric



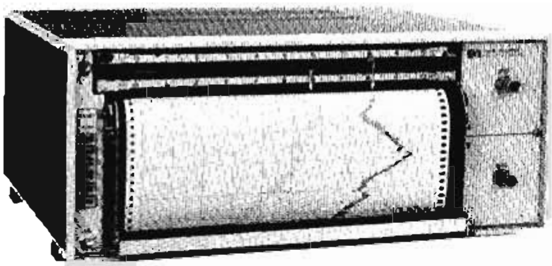
040, 046 Limit Switch

10-INCH TWO-PEN RECORDERS

Ink Writing

Models 7130A, 7130B

NEW



7130A

The 7130A and 7130B are single-span, 10-inch, two-pen strip chart recorders. The 7130A operates on a 60 Hz line; 7130B on 50 Hz. Input spans from 1 mV to 100 V are available and chart speeds in either single or multiple speeds are available. The chart paper has a 10-inch (25 cm) writing width and feeds from the top to the bottom over a platen that can be tilted at one of three angles. The tilting platen facilitates both viewing and making of notations by hand. Low cost, peak performance, and top reliability are featured, plus a selection of over fifty options to allow custom tailoring to each application.

Performance Specifications

Input ranges: single span, 1 mV thru 100 V (specified by option).
Type of input: single ended, floating.
Input resistance: 1 Megohm constant on all spans.
Maximum allowable source resistance (R_s): no restriction.
Normal mode rejection (at line frequency): >40 dB.
Common mode rejection: >120 dB at dc and >90 dB at line frequency.
Response time: <½ sec.
Overshoot: <2% of full scale.
Accuracy (including linearity and deadband): ±0.2% of full scale.
Linearity (terminal based): ±0.1% of full scale.
Chart speeds: speed determined by option choice.
Chart speed accuracy: synchronous with line frequency.
Zero set: left hand, adjustable ±1 full scale (right hand optional).
Environmental (operation): 0°C to 55°C, <95% relative humidity (40°C).

General specifications

Writing mechanism: servo actuated ink pens.
Grid width: 10" or 25 cm.
Chart length: 100 ft or 30 meters.
Pen lift: manual (electric optional).
Power: 7130A: 115/230 V ±10%, 60 Hz, 120 VA.
7130B: 115/230 V ±10%, 50 Hz, 120 VA.
Dimensions: 7" high, 17" wide, 13⅜" deep (178 x 432 x 340 mm).
Weight: net, 27 lb (12.3 kg); shipping, 38 lb (17,4 kg).
Price: 7130A or 7130B: $1250
Note: OEM discounts available.

Options

Span: *specify one for each channel, front scale determined by choice of English or metric chart speed.*

Span	Option Ch 1	Option Ch 2	Price	Span	Option Ch 1	Option Ch 2	Price
1 mV	001	501	$150	1 V	008	508	N/C
5 mV	002	502	150	5 V	009	509	N/C
10 mV	003	503	100	10 V	010	510	N/C
50 mV	004	504	100	50 V	011	511	N/C
100 mV	005	505	100	100 V	012	512	N/C
500 mV	006	506	100				

Note: additional spans are available on special order.

Chart speed, *specify one option:*

Speed	Option	Price	Speed	Option	Price
6 in./min	016	N/C	15 cm/min	022	N/C
4 in./min	017	N/C	10 cm/min	023	N/C
1 in./min	018	N/C	5 cm/min	024	N/C
½ in./min	019	N/C	3 cm/min	025	N/C
¼ in./min	020	N/C	15 cm/hr	026	N/C
1 in./hr	021	N/C	3 cm/hr	027	N/C

Speed	Option	Price
1, 2, 4, 6 in./min	045	$180
¼, ½, 1, 2, in./min	046	150
2.5, 5, 10, 15 cm/min	048**	180
1.25, 2.5, 5, 10 cm/min	049	150

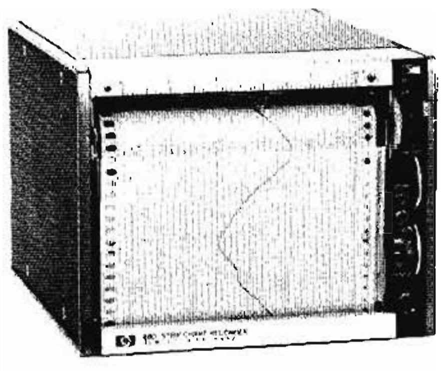
Chart speed control:	Option	Price
60:1 speed reducer	028	$40
10:1 speed reducer	029	40
4:1 speed reducer	030	40
2:1 speed reducer	031	40
Remote speed change*	032**	20
Remote chart On-Off*	033**	20

Pen lift control:	Option	Price
Remote*	036**	$40
Independent (mechanical)	034	N/C
Input Filter (1-500 mV)	007	30
Event Marker		
Right hand	037**	40
Left hand	537**	40

	Ch 1	Ch 2	Price
Retransmitting Potentiometer	040	540	$50
Limit Switches	044	544	40
Right Hand Zero			
Hard (scale, 10 to 0)		014	N/C
Soft (scale, 10 to −0.5)		015	N/C
Rack Slides		042	65
Rack Mounting Brackets		052	10
Rear Control connector		056	10
Option Power Supply (required for Option 032, 033, 036, 037, 048 and 537)		041	40

*Actuated by contact closure to ground. Closed circuit current 1.5 mA (max), open circuit voltage +1.5V (max).
**Requires Option Power Supply (Option 041).

5 in. COMPACT RECORDER
Ink or electric writing
Model 680



680 Series

The Models 680 and 680M 5-inch strip-chart recorders provide a wide range of performance for general or specialized use. The 680 is equipped with multi-range input, multi-speed chart transport, full-range zero set, and electric pen lift, features essential for general purpose applications. The instrument is available with standard (English) or metric scaling (680M). It is useful as a monitor for instrumentation with dc outputs and for digital devices utilizing D-A converters.

The recorder features modular construction with all-transistor circuitry, high accuracy, fast response, synchronous motor chart drive, and full-view tilting chart magazine. Standard features include instant chart speed transfer, local and remote pen lift control, tear-off or chart roll storage, and cartridge-fed ink pen. Optional electric writing provides crisp, clean, permanent records for long-term unattended recording.

Specifications

Performance specifications

Recording mechanism:

Ink: servo-actuated ink pen.

Electro sensitive: a stylus and associated electronics for electrosensitive paper are furnished in place of the ink pen.

Chart dimensions:

Ink: 6" by 100' roll charts, 5" (12 cm) writing width. Approximately 4" by 6" visible chart area during operation.

Electrosensitive: 6" by 65' roll charts, 5" (12 cm) writing width.

Response time: one-half second or less for full scale.

Chart speeds: eight synchronous-motor-controlled speeds at 1, 2, 4, 8 in./min; 1, 2, 4, 8 in./hr. Metric model: 2.5, 5, 10, 20 cm/min; 2.5, 5, 10, 20 cm/hr.

Spans: ten calibrated spans of 5, 10, 50, 100, and 500 mV; 1, 5, 10, 50, and 100 V full scale. Metric model has spans of 6, 12, 60, 120, and 600 mV; 1.2, 6, 12, 60, and 120 V. An extra span of 1 mV, full scale, is available at extra cost (1.2 mV on metric model).

Input: input resistance is 200,000 ohms per volt (166,666 ohms/volt on metric models), full scale, through 10 volt span; 2 megohms on all others. Potentiometric input on most sensitive span permits operation with essentially zero current drain at null. Constant 100 kΩ input resistance on all spans optionally available on both models.

Reference stability: ±0.005%/°C.

Zero set: continuously adjustable over full recorder span.

Accuracy: better than 0.2% of full scale.

Resettability: 0.1% of full scale.

Linearity: 0.1%.

Interference rejection: dc common mode rejection better than 100 dB on the most sensitive range.

General specifications

Pen lift: local and remote.

Power requirements: 115/230 V, 60 Hz, 22 VA. 50 Hz models available at no extra cost, (Option 10).

Dimensions: 6½" high, 8⅝" deep, 7¾" wide (165 x 219 x 197 mm). Rack mounting requires 7" (178 mm) of vertical space.

Weight: net, 11 lb (5 kg); shipping, 17 lb (7,6 kg).

Accessory kit supplied: spare pen, syringe, remote pen lift mating connector, pen cleaning wire, slidewire cleaner and lubricant, 8 ink cartridges (4 red and 4 blue), and one roll of chart paper.

Price: Model 680 (English) or 680M (Metric) $900

Options:

001	With installed 5Ω, 0.1% linearity retransmitting potentiometer	add $ 50
002	With ink event marker installed	add $ 35
003	With installed high-low limit switches	add $ 90
008	With 16/1 instead of 60/1 speed reducer	add $ 25
009	With remote chart drive switch	add $ 25
010	For 50 Hz operation	N/C
013	For operation with 7560A, 7561A	add $ 25
014	Glass door with lock	add $ 45
015	Electric writing (special paper required)	add $100
016	Electric writing event marker	add $ 45
018	Disposable pen tips	N/C
H01	1 mV span added (H01-680)	add $ 50
	1.2 mV span added (H01-680M)	add $ 50
H02	100 kΩ input resistance, all spans	add $ 75

Note: *ink and electric systems are not combatible. Event markers must be the same type as the main writing system. Options H01 and H02 not compatible.*

DIGITAL TO ANALOG CONVERTERS

For high resolution recording

Models 580A, 581A

Digital-to-Analog Converters make possible automatic, high-precision analog records from electronic counters, digital voltmeters and other devices providing the proper 4-line BCD output code. These converters operate directly with HP Quartz Thermometers, HP Nuclear Scalers and most HP solid-state counters; output kits are available for HP vacuum tube counters. Since the digital-to-analog converters tolerate a wide range of input voltages, they are suitable for use with other tube and solid-state devices.

Output signals for strip-chart or x-y recorders of both the potentiometer and galvanometer types are available, and controls for recorder calibration and zero adjustment are provided. A 50-pin connector accepts 4-line data from a maximum of nine decade counting units. This information is transferred to storage binary units upon receipt of a command pulse from the counting source. The stored data are then translated and weighted to provide the proper analog output voltage or current.

Any three successive digits (or the right-hand two) of the input may be chosen for analog output. By selecting the two or three least significant digits, analog records of high resolution and accuracy may be obtained with conventional strip chart and X-Y recorders. For example, recording the three right-hand digits of eight- or nine-column data can provide an analog record with resolution of 1 part in 10^8.

Since the data in three successive columns can range only from 000 to 999, automatic zero-shifting is inherent in the output, keeping the record "on scale" at all times. As an example, consider successive readings of: 000, 120, 257, 496, 732, 998, 1024. Except for the last reading, the analog record would proceed up-scale to 998 (99.8% of full scale). Recording of the 1024 value would be made at 024 (2.4% of full scale). The quick transition of the pen from 998 to 024 would serve to indicate that the range has been shifted up by 1000. Down-scale shifts of zero are similarly indicated.

Specifications, 580A, 581A

Accuracy: 0.5% of full scale or better.

Potentiometer output: 100 mV full scale; minimum load resistance 20 K; calibrate control; dual banana plugs front and rear; typical 5 mV residual output at "000".

Galvanometer output: 1 mA full scale into 1500 ohms; zero and calibrate controls; phone jack front and rear.

Driving source: parallel entry 4-line BCD 4-2-2-1 (9 digits maximum); "1" state +4 to +75 volts with reference to "0" state.

Reference voltages: reference voltages required for both the "0" and "1" state, reference voltages not to exceed ±150 V to chassis.

Command pulse: positive or negative pulse, 20 μs or greater in width, 6 to 20 volts amplitude.

Transfer time: 1 millisecond.

Power: 115 or 230 volts ±10%, 50 to 1000 Hz, 11 W.

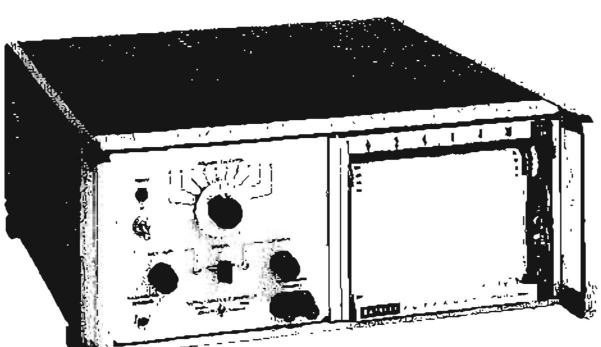
Options: please specify one of the following input code options (Option 001, 002, or 003):
- 001: 1-2-2-4 BCD code "1" state positive; "1" state +4 to +75 V with reference to "0" state. No additional cost.
- 002: 1-2-4-8 BCD code "1" state positive (voltages same as above). No additional cost.
- 003: 1-2-4-8 BCD code "1" state negative; "0" state +4 to +75 V with reference to "1" state. No additional cost.
- 004: Special input cable 10513A for HP integrated circuit counters (e.g., 5221B, 5216A, 5331A/B, 5332A/B, 5325A) in lieu of 562A-16C input cable normally supplied. Add $15.00.

Dimensions:
- 580A (rack mount): 16¾" wide, 3-15/32" high, 11¼" deep (425 x 88 x 286 mm).
- 581A: 7-25/32" wide, 6-3/32" high, 8" deep (198 x 155 x 203 mm).

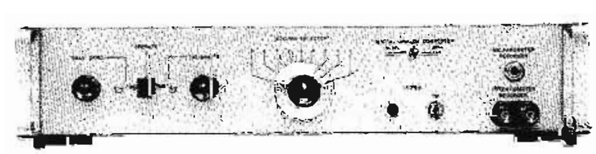
Weight:
- 580A:
  - net: 13 lbs (6 kg)
  - shipping: 16 lbs (7,2 kg)
- 581A:
  - net: 8 lbs (3,5 kg)
  - shipping: 13 lbs (6 kg).

Accessory furnished: 562A-16C Cable, 6' (1830 mm) long with an Amphenol 57-30500 connector at each end. See also Option 004.

Price:
- Model 580A, $675.
- Model 581A, $675.



581A with 680 Recorder



580A

A wide need exists in data recording for continuous, highly visible records of analog signals. Permanent records of signals from dc to 150 Hz can be made conveniently and reliably using Hewlett-Packard oscillographic recorders.

Writing systems

Both ink and thermal writing systems are available. Ink writing systems incorporate an ink supply that operates at low pressure, ensuring uniform traces at all chart speeds and over all points of the waveform. The recording fluid, a permanent ink, permits high resolution copying of recorded data. The disposable ink cartridges are easily and cleanly replaced.

Thermal writing systems use a heated stylus technique to produce chart traces on heat-sensitive Permapaper®. Features include an absolutely reliable writing method, a resolution of 4 cycles per mm of paper travel even at small amplitudes, and unattended operation for greatly extended time periods with an optional 1000 foot paper supply.

Ink writing recorder systems

Two basic ink writing recorder systems exist. The first is the new 2-channel 7402A, a portable general purpose recorder which uses the 17400 Series plug-in preamplifiers. The second basic recorder system consists of the rack mounted 8-channel 7858B and 7878A. The 7858B uses the 8800 Series of plug-in preamplifiers whereas the 7878A uses bank amplifiers, either the 8820A or the 8821A.

Thermal writing recorder systems

There are two basic thermal writing recorder systems. One is the portable 2-channel 7702B; the second consists of the rack mounted, 6, 8, and 16-channel systems.

Plug-in preamplifiers

Two plug-in series are available, the 17400 Series and the 8800 Series. The new and still expanding 17400 Series is presently used with the 2-channel portable oscillographic recorder. The 8800 Series is used with all other recording systems that accept plug-in signal conditioners. This series may also be used independently of the recorder as lab preamplifiers, when used with the bench-top power supply available as an option with each unit.

Bank amplifiers

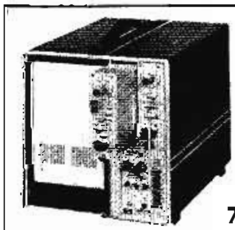
Two bank amplifiers are available for general purpose applications where the versatility of plug-ins is not needed. Each model is available in 6 or 8-channel versions.

The 8820A Low Gain Amplifier provides 7 input ranges from 50 mV/div to 5 V/div in a 1, 2, 5 sequence. Each input is single ended, with 1 MΩ input resistance. All channels have lockable, front-panel gain vernier and zero position controls.

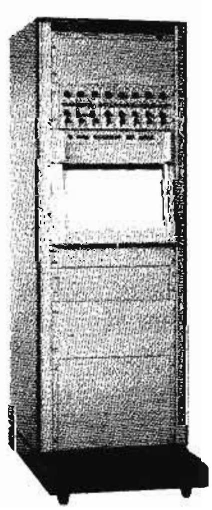
The 8821A has 12 input ranges from 1 mV/div to 50 mV/div and 0.1 V/div to 5 V/div. Input on the mV/div ranges is floating and guarded with 9 MΩ input resistance and 100 dB CMR at 60 Hz. On the V/div ranges the input is balanced to ground, with 4.5 M to ground on each side. CMR on these ranges is 66 dB at 60 Hz. Internal calibration of ±20 mV, ±1% on the mV/div ranges and +2 V, ±2% on the V/div ranges is standard.

Ordered separately, prices are: Model 8820A 6-channel, $1220; 8-channel, $1250; Model 8821A, $2300 and $2500.

Oscillographic recorder system specifications



7402A

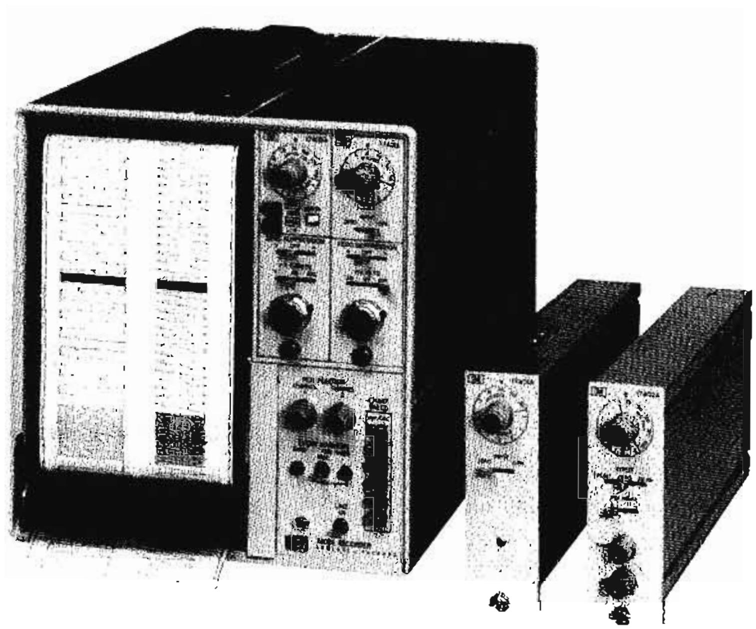


7858A

System	Number of Channels, Chart Width	Writing Method	Preamplifier Configuration	With Amplifier Model No.	Maximum Sensitivity (mV/div)	Frequency Response (−3 dB @ 10 div)	Rise Time 10% to 90% (ms, 10 div)	Vertical Rack Space Requirement
7402A	2 x 50 mm	Ink	Plug-in	17400A 17401A 17402A	.001 1 20	125 Hz 140 Hz 140 Hz	7.5 (50 mm) 7 (50 mm) 7 (50 mm)	10½″
7702B	2 x 50 mm	Thermal	Plug-in	8801A 8802A 8803A	5 1 .001	125 Hz 125 Hz 90 Hz	5 5 7	8¾″
7414A	4 x 50 mm	Thermal	Plug-in	8801A 8802A 8803A	5 1 .001	100 Hz 100 Hz 80 Hz	5 5 7	10½″
7706B	6 x 50 mm	Thermal	Plug-in	8801A 8802A 8803A	5 1 .001	125 Hz 125 Hz 90 Hz	5 5 7	26¼″
7727A	6 x 50 mm	Thermal	Bank	8820A 8821A	50 1	125 Hz 125 Hz	5 5	24½″
7708B	8 x 40 mm	Thermal	Plug-in	8801A 8802A 8803A	5 1 .001	150 Hz 150 Hz 100 Hz	4 4 6.4	26¼″
7858B	8 x 40 mm	Ink	Plug-in	8801A 8802A 8803A	5 1 .001	150 Hz 150 Hz 100 Hz	3 3 5.5	31½″
7729A	8 x 40 mm	Thermal	Bank	8820A 8821A	50 1	150 Hz 150 Hz	4 4	24½″
7878A	8 x 40 mm	Ink	Bank	8820A 8821A	50 1	150 Hz 150 Hz	3 3	29¾″
7731A	16 x 20 mm	Thermal	Bank	8820A 8821A	100 2	125 Hz 125 Hz	4 4	29¾″

DUAL-CHANNEL RECORDER
Ink Writing, 50 mm Channels
Model 7402A

NEW▶



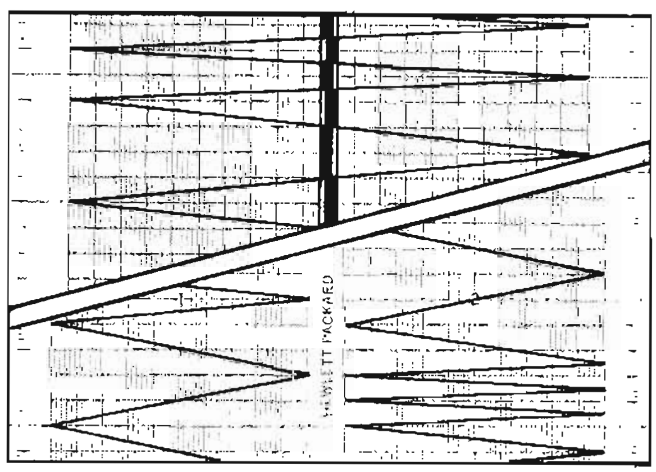
Model 7402A is a portable, ink writing oscillographic recorder that records on either two 50 mm channels or a single 100 mm channel. This unit also features instant drying ink, long-life pens, easy paper loading, and a new series of plug-in signal conditioners. These plug-ins, the 17400 Series, presently consist of a high gain, a medium gain, and a low gain DC Preamplifier—the first in a new and expanding series.

The pressurized inking system produces a clear, crisp trace that dries immediately on contact with the paper. The black ink color will photocopy with clarity. Solidly built, the pen is constructed of stainless-steel and provided with a tough carbide tip. Pens will last the life of the instrument; periodic lapping and force adjustments are not required.

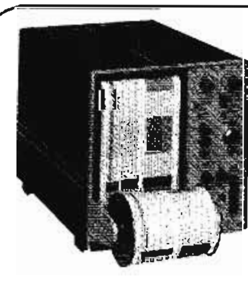
The trace is recorded on an easy loading, 275 ft (84 m) roll of chart paper. Four chart speeds are provided, selected by front panel pushbuttons. Remote control of the chart speed, also standard, includes the four chart speeds plus chart stop. Remote control is by either contact closure or TTL level.

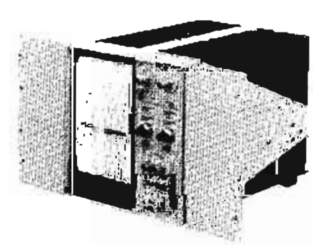
The frame is modular in design, all major assemblies may be easily removed. All circuit boards are removable from the rear of the unit.

100 mm Trace



Dual 50 mm Trace





Performance specifications

	With 17400A	With 17401A	With 17402A
Input Ranges:	1, 2, 5, 10, 20, 50, 100, 200, 500 μV/div; 1, 2, 5, 10, 20, 50, 100, 200, 500 mV/div; 1, 2, 5 V/div. Continuous vernier between ranges.	1, 2, 5, 10, 20, 50, 100, 200, 500 mV/div; 1, 2, 5 V/div. Continuous vernier between ranges.	20, 50, 100, 200, 500 mV/div, 1, 2, 5 V/div. Continuous vernier between ranges.
Type of Input:	Differential, floated, and guarded. Inputs thru rear connector.	Balanced-to-ground. Inputs thru rear connector.	Single-ended. Inputs thru rear or front connectors.
Maximum Allowable Input: (Continuous)	500 V dc on 10 mV/div range and above; other ranges, 120 V dc or 120 V ac rms (500 V peak).	250 V rms on 500 mV/div and above; 115 V rms (230 V rms for 1 sec) max on other ranges.	250 V rms on 500 mV/div and above; 115 V rms (230 V rms for 1 sec) max on other ranges.
Input Resistance:	1 Megohm (minimum).	500 k ohms each side to ground.	1 Megohm
Common Mode Rejection: DC	150 dB; 90 dB on 10 mV/div and above.	>50 dB	
AC	140 dB; 80 dB on 10 mV/div and above. (1 k ohm source unbal)	>50 dB (100 ohm source unbal)	
Maximum Allowable Common Mode Voltage:	200 V dc or peak ac.	250 V dc or peak ac on 500 mV/div and above; other ranges 15 V dc or peak ac.	
Frequency Response: 100 div	+0%, −6% of full scale from dc to 27 Hz at 5 μV/div and above; 25 Hz at 2 μV/div; 24 Hz at 1 μV/div. −3 dB at 46 Hz, 5 μV/div and above.	±2% of full scale from dc to 25 Hz. −3 dB at 48 Hz.	±2% of full scale from dc to 25 Hz. −3 dB at 48 Hz.
50 div	+0%, −6% of full scale from dc to 40 Hz at 5 μV/div and above; 28 Hz at 2 μV/div; 15 Hz at 1 μV/div. −3 dB at 55 Hz, 5 μV/div and above.	±2% of full scale from dc to 40 Hz. −3 dB at 55 Hz.	±2% of full scale from dc to 40 Hz −3 dB at 55 Hz.
10 div	−3 dB at 125 Hz at 5 μV/div and above; 80 Hz at 2 μV/div; 45 Hz at 1 μV/div.	−3 dB at 140 Hz.	−3 dB at 140 Hz.
Rise Time: (Typical, 10% to 90% of 50 mm or 100 mm deflection)	7.5 msec	7 msec	7 msec
Overshoot[1]:	<2% of full scale.	2% of full scale.	2% of full scale.
Accuracy:	±0.75% of full scale ±0.06%/°C	±0.75% of full scale ±0.06%/°C	±0.75% of full scale ±0.06%/°C
Linearity[1]:	±0.6% of full scale.	±0.6% of full scale	±0.6% of full scale.
Zero[2]:	Adjustable to 30 mm either side of grid center. Position stability ±0.1 mm/°C.		
Zero Suppression:	1, 10, 100 V on 10 mV/div range and above; other ranges 1, 10, 100 mV. Continuous calibrated vernier between suppression steps.	(OPTIONAL) 0.2, 2, 20 V, continuous calibrated vernier between suppression steps.	
Zero Suppression Accuracy[1,2]:	±0.5% of suppression ±0.5% of full scale. ±0.02%/°C.	±0.5% of suppression ±0.5% of full scale. ±0.02%/°C.	
Chart Speeds:	1, 5, 25, 125 mm/sec. Front panel or remote selection, including STOP, via contact closure or TTL level.		
Chart Speed Accuracy:	±0.5% plus power line frequency variation from 60 Hz.		
Chart Weave:	±0.25 mm	±0.25 mm	±0.25 mm
Environment (operating):	0°C to 55°C and <95% relative humidity (40°C.)		

General specifications

Writing System:	Blue-black ink with rectilinear presentation.
Ink Capacity:	55 cc replaceable, throw-away cartridge. Sufficient for 12 months of typical operation.
Number of Channels:	Two 50 mm or one 100 mm channel plus one optional event and one optional event/timer channel.
Chart Description:	Two channels each 50 mm wide with 50 div or one channel 100 mm wide with 100 div, time lines every 1 mm. Chart length is 275 ft (84 m) with the last 20 ft. (6.1 m) indicated by a colored stripe.
Chart Take-Up:	External roll (optional).
Dimensions:	9-15/16" wide, 11-3/16" high, 15-1/8" deep (252 x 284 x 384 mm). Rack mounting height (Opt 006) is 10-15/32" (266 mm).
Power:	115/230 V ac ±10%, 60 Hz, 140 VA.
Typical System Weight:	Net 40 lb. (18,4 kg); shipping 59 lb. (27,2 kg).

Prices:

7402A Mainframe (less plug-ins)	$1450
17400A High-Gain Preamplifier	675
17401A Medium-Gain Preamplifier	225
Option 001 (Zero Suppression)	add 125
17402A Low-Gain Preamplifier	145

Options:

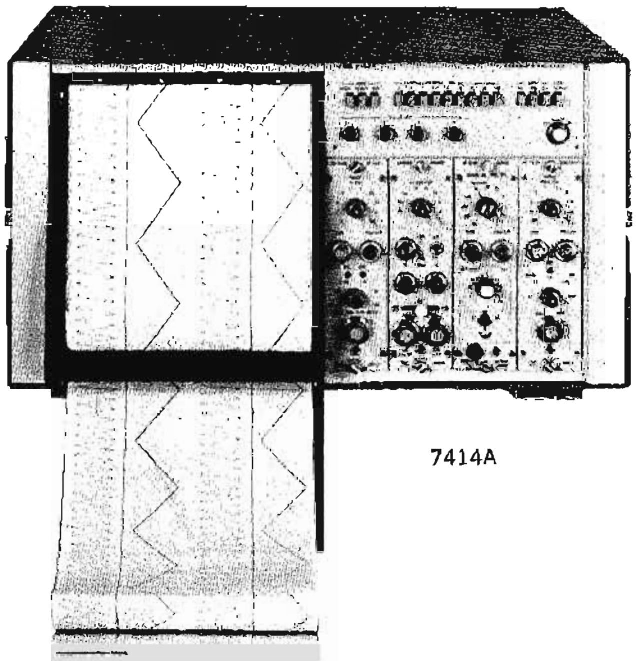
001	Event Marker (left hand)	$ 65
002	Event Marker and Timer (right hand)	100
003	Both Event Marker and Event Marker/Timer	160
004	50 Hz Power Line Operation	N/C
005	Paper Take-Up (external)	110
006	Rack Mount Adaptor	50

[1] This specification is based on a full scale of 50 mm. For 100 mm full scale operation, the "% of full scale" figure is one-half the stated value.
[2] For 100 mm full scale operation the ZERO Control position remains fixed, the ZERO SUPPRESSION Control is used as a "ZERO Control".

4-CHANNEL THERMAL TIP

Bench-top operation, plug-in preamps

Model 7414A



7414A

Contained in a single benchtop package, the 7414A represents a unique combination of convenience, high performance and flexibility. Incorporated are thermal writing and positive position feedback plus the capability to accept the entire complement of the 8800 series plug-in signal conditioners. In addition to the benchtop package, the 19-inch unit may be rack mounted or mounted in an optional mobile cart.

The thermal writing tip features high contrast writing, long stylus life, and rectilinear presentation. A closed-loop, contactless pen position feedback system results in 0.5% linearity. The system provides flat response (±0.5 dB) to 50 Hz at full scale amplitude.

The 500 foot Z-fold pack loads in 30 seconds from the front with no threading. Z-fold allows for convenient data review and storage. Nine pushbutton chart speeds are provided ranging from 0.25 to 100 mm/s.

Specifications

Writing system: thermal with rectilinear presentation.

Chart speeds: 0.25, 0.5, 1, 2.5, 5, 10, 25, 50, 100 mm/s; electrically selected by front panel pushbuttons.

Chart accuracy: speed, synchronous with line ±1%; weave, 0.5 mm.

Chart description: four channels, each 40 mm wide divided into 50 divisions, with time lines every 1 mm, Z-fold, heat-sensitive Permapaper®, packs of 500 sheets, each sheet 11.9" (30.1 cm) long and numbered on the right side for footage indication and indexing.

Limiting: factory set 1.5 mm outside grid. Settable, by internal screwdriver adjustment, from 2 mm outside to 8 mm inside grid.

Markers: one event marker and one combination event/timer marker in second and fourth margins. Third event marker is optional.

Remote operation: rear connector provides for remote operation of chart drive and event marker.

General

Power: 115/230 V ±10%, 60 Hz, 350 VA (including signal conditioners). 50 Hz operation optional.

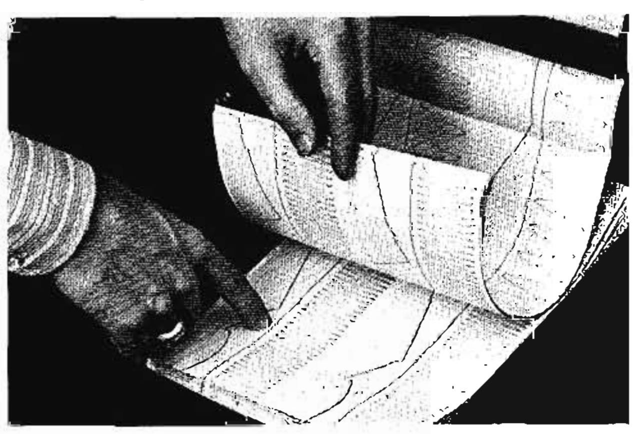
Weight: net, 112 lbs (50,5 kg); shipping, 132 lbs (59,5 kg).

Dimensions: cabinet: 11⅞" high, 20⅛" wide, 24" deep (302 x 511 x 604 mm); rack mount: 10½" x 19" x 24".

Price: Model 7414A (less preamplifiers) $4500

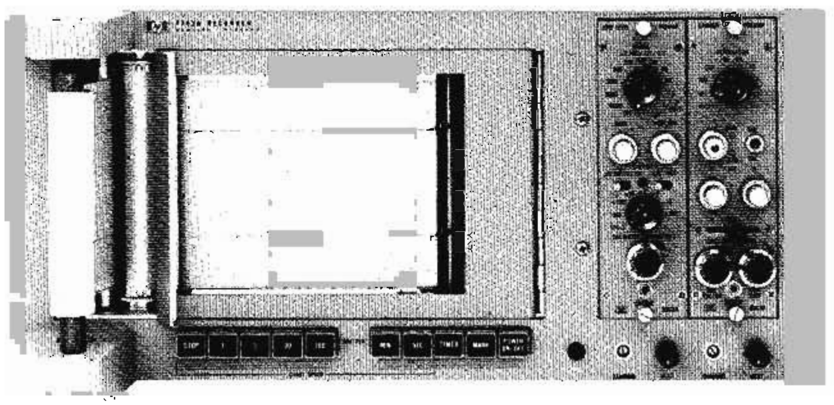
Options

001	rack mount; includes slides and all mounting hardware. Deletes case	N/C
008	50 Hz operation	$ 35
012	1 channel decrease; extreme right hand channel deleted, blank panel installed for plug-in. Not compatible with Option 015	deduct $ 200
015	extra event marker, installed between channels 2 and 3. Not compatible with Option 012	$ 35
054	installed in mobile cart. Includes paper take-up drawer	$ 450



DUAL-CHANNEL RECORDER

Mount in cart, cabinet or portable case
Model 7702B



7702B

Specifications

(Full performance specifications determined by choice of 8800 Series Preamplifier, see following pages.)

Chart speeds: four speeds standard (1, 5, 20 and 100 mm/s) mechanically shifted and selected by front panel pushbuttons; other speed combinations available as options; provision is made for optional remote control of chart drive from suitable 115 V ac source.

Timer-off-marker: separate stylus marks edge of chart with 1 s pulses in TIME position or with line frequency pulses in MARK position; remote marking provision at rear connector by simple contact closure (115 V ac).

Front panel controls: individual stylus heat controls; pushbuttons for power, timer, marker and speed selection; individual galvanometer damping adjustments (screwdriver adjust).

Paper: standard 200 ft rolls of 5 cm wide, 2-channel Permapaper® (651-52), easily loaded from the recorder front panel; 1-channel Permapaper® (651-51), may be used if only one channel is operated; orange, translucent Permapaper® (651-182), is available for making multiple copies of recording on contact copier (ozalid).

Paper take-up: automatic paper take-up standard equipment.

Power: 115/230 V ±10%, 60 Hz, approx 200 VA; 115/230 V ±10%, 50 Hz, available in Option 008.

Dimensions: rack mounted: 8¾" high, 19" wide, 17" deep (222 x 483 x 432 mm); portable case (Option 002): 10-7/16" high, 20⅞" wide, 21-13/16" deep (265 x 530 x 576 mm); mobile cart (Option 005): 39¼" high, 26¾" wide, 20½" deep (997 x 680 x 521 mm).

Weight (approx): typical with 2 preamplifiers, rack mounted: 60 lb (27,2 kg) net; 89 lb (40,4 kg) gross; portable case (Option 002): 89 lb (40,4 kg) net; 135 lb (60,8 kg) gross; mobile cart (Option 005): 130 lb (59 kg) net; 172 lb (77,4 kg) gross.

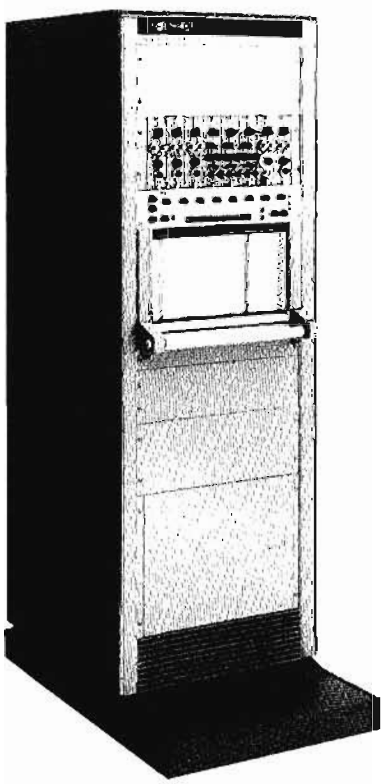
Price: two channel thermal recorder, 115/230 V switch, 60 Hz, for rack mounting, uses 8800 Series Preamplifiers, specify Portable Case or Mobile Cart by Option $2050

Options

002	Portable case	add $ 195
003	One channel decrease	deduct $ 50
005	Mobile cart (1062A)	add $ 195
008	50 Hz operation	add $ 50
009	Speeds, 2.5, 5, 25 and 50 mm/sec (50 Hz)	add $ 75
010	Speeds, 2.5, 5, 25 and 50 mm/sec (60 Hz)	N/C
011	60:1 Speed Reduction (60 Hz) (includes one-minute marker)	add $ 185
012	60:1 Speed Reduction (50 Hz)	add $ 185
015	Extra Marker between channels	add $ 76
018	60 Hz, 2:1 reduction, speeds of 0.5, 2.5, 10 and 50 mm/sec	add $ 175
019	50 Hz, 2:1 reduction, speeds of 0.5, 2.5, 10 and 50 mm/sec	add $ 175

Note 1: add price of preamplifiers to the above basic assembly prices for complete system cost; see following pages for specifications and prices.

THERMAL WRITING SYSTEMS
6, 8, and 16 channels
7706B, 7708B, 7727A, 7729A, 7731A



7708B

Multichannel thermal recording systems are available with either bank preamplifiers (all preamps of same type) or with individual 8800-series preamps for long-term system versatility.

Galvanometer power amplifiers incorporate damping circuits to ensure recorder accuracy, current feedback to reduce drift and adjustable electrical limiting to prevent overloading and to protect the styli.

Four and six channel paper may be used for economy when recording less than the maximum number of channels. Permapaper® in opaque or translucent forms is available.

Systems may be obtained in RETMA standard mobile cabinets, less cabinet for mounting in RETMA standard equipment racks, or in portable cases.

Specifications

(Overall system performance specifications are determined by choice of plug-in or bank amplifier. See page 225.)

Chart speeds: 0.25, 0.5, 1, 2.5, 5, 10, 25, 50, 100 mm/s, electrically shifted and selected by front panel pushbuttons; provision is made for remote operation of chart speeds and chart drive.

Event marker: right margin; built-in timer provides 1 s timing marks; manual or remote operation from contact closure. Optional event marker can be installed between channels.

Front panel controls: individual stylus heat controls; pushbutton speed selectors; motor starting switch; timer-off-marker switch.

Chart footage indicator: front panel indicator shows number of feet remaining on the supply roll.

Chart type: green or translucent Permapaper®, 200 ft long.

General

Power: 115 V ±10%, 60 Hz; approx 330 VA; 7731A requires approx 550 VA.

Dimensions: mobile cabinet mount: 72½" high, 24" wide, 36½" deep incl base (1842 x 610 x 927 mm); rack mount: 19" wide, 24⅛" deep, see height on page 225.

Prices

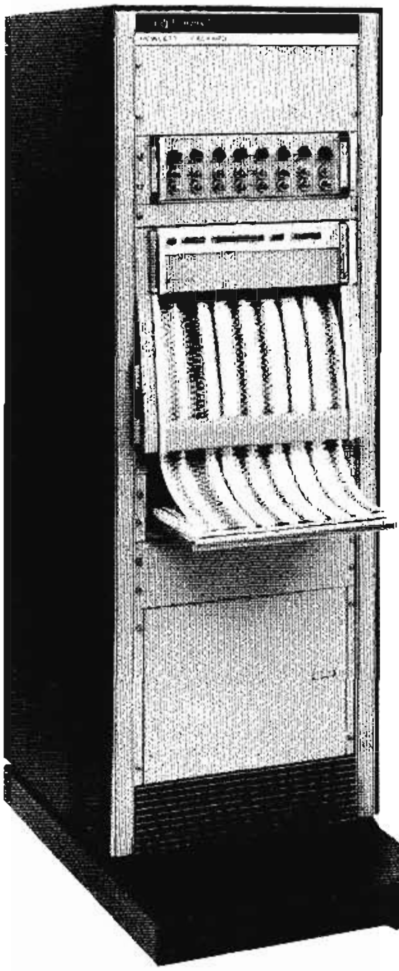
Model 7706B	$ 5550
Model 7708B	$ 6375
Model 7727A	$ 4600
Model 7729A	$ 5000
Model 7731A	$10000

Options

001	less cabinet, for rack mounting		
	7706B, 7708B	deduct	$ 395
	7727A, 7729A, 7731A	deduct	$ 425
002	less cabinet, mounted in portable cases		
	7706B, 7708B	add	$ 150
	7727A, 7729A	deduct	$ 75
008	50 Hz operation		$ 50
009	230 V operation		$ 100
011	(60 Hz) 9 additional speeds (mm/min)		$ 250
012*	one channel decrease	deduct	$ 50
013*	two channel decrease	deduct	$ 100
016	(60 Hz) 2:1 increase of standard speeds		$ 75
017	(50 Hz) 2:1 increase of standard speeds		$ 75
020	with 8820A amplifier		
	6 channel (7727A)		$ 1250
	8 channel (7729A, 7731A)		$ 1250
021	with 8821A amplifier		
	6 channel (7727A)		$ 2300
	8 channel (7729A, 7731A)		$ 2500
024*	less 440 Hz card (do not order if using 8803A)	deduct	$ 50
025*	less 2400 Hz card (do not order if using 8805A/B)	deduct	$ 50
027	(60 Hz) 2½:1 reduction of standard speeds		$ 140
028	(50 Hz) 2½:1 reduction of standard speeds		$ 140
029	(50 Hz) 9 additional speeds (mm/min)		$ 250
031-037**	extra marker between channels (31 between 1 and 2, 32 between 2 and 3, etc.)		$ 70
040**	dc marker amp (for use with Options 031-037)		$ 110
041**	with hidden paper take-up		$ 475

* Applicable to 7706B, 7708 only.
** Not applicable to 7731A.

INK WRITING SYSTEMS
Systems record on Z-fold paper or rolls
Models 7858B, 7878A



7878A

The models 7858B and 7878A are eight-channel, modulated pressure ink recording systems. The systems feature contactless position feedback from the pen tip, the convenience of Z-fold paper take-up, and the economy of ink-writing paper. All operating controls are front-panel accessible.

Fourteen chart speeds (0.025 to 200 mm/s) are standard, and conveniently selectable by front-panel pushbuttons. A left-hand edge marker pen provides 1 s or 1 min indications (also switch selected from front panel) for accurate time correlation. A right-hand marker pen permits event or time code monitoring. A front-panel warning light indicates when the ink supply is low and a new cartridge is required. An additional indicator can also be lighted at a remote location.

A remote connector on the recorder rear panel enables an operator to select the desired chart speed and to activate the 1 s or 1 min markers from a remote location. The functions are activated by simple contact closures.

Z-fold chart paper permits immediate access to any data without interrupting the recorder; it comes in 500-sheet packs, perforated so that individual sheets can be removed from the pack. Both roll and Z-fold paper are printed with eight 40 mm wide channels, 50 divisions/channel, with timing lines every millimeter. Rolls are 500 ft long, and Z-fold packs are 500 sheets x 30 cm (11.8″) per sheet.

The low pressure ink system is modulated to match the recording pen velocity and chart speed, assuring sharp, constant width traces under all signal input conditions. The recording fluid is a permanent blue ink that dries rapidly on contact with the recording paper. The disposable ink cartridge can be replaced anytime—even while the system is operating— permitting uninterrupted tracings. One cartridge supplies over 1000 miles of recorder line.

Systems may be obtained in RETMA standard mobile cabinets, less cabinet for mounting in RETMA standard equipment racks, or in portable cases.

Specifications

(Overall system performance specifications are determined by choice of plug-in or bank amplifier. See page 225.)

Ink system: disposable, plug-in cartridge can be replaced while operating system; ½ hour reserve.

Chart speeds: 0.025, 0.05, 0.1, 0.25, 0.5, 1, 2, 2.5, 5, 10, 25, 50, 100, 200 mm/s, pushbutton selected.

Paper takeup: internal roll accessible by pivoting writing table; Z-fold takeup is below recorder; no modification required to change between roll and Z-fold paper.

Limiting: electrical, from ±12 div (referenced from channel centerline) to beyond channel edge.

Remote operation: connector provided for remote operation of chart drive, chart speed selector and timer/marker. Provides a positive voltage to indicate remote readiness.

General

Power: 115 V ±10%, 60 Hz, approx 600 VA. 50 Hz available as Option 008; 230 V operation as Option 009.

Weight: in cabinet with preamplifiers, approx 550 lbs (249 kg).

Dimensions: mobile cabinet mount: 72½″ high, 24″ wide, 36½″ deep incl base (1842 x 610 x 927 mm); rack mount: 19″ wide, 23″ deep, see height on page 225.

Prices

Model 7858B (cabinet, less preamplifiers)	$10350
Model 7878A (cabinet, less preamplifiers)	$ 9500

Options

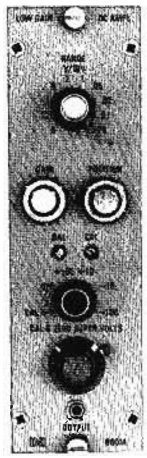
001	less cabinet, for rack mounting	deduct $ 425
002	less cabinet, mounted in portable cases	N/C
008	50 Hz operation	$ 50
009	230 V operation	$ 100
012*	one channel decrease	deduct $ 200
013	two channel decrease	deduct $ 400
020	with 8820A amplifier (7878A only)	$ 1250
021	with 8821A amplifier (7878A only)	$ 2500
024*	less 440 Hz card (do not order if using 8803A)	deduct $ 50
025*	less 2400 Hz card (do not order if using 8805A/B)	deduct $ 50

* Applicable to 7858B only.

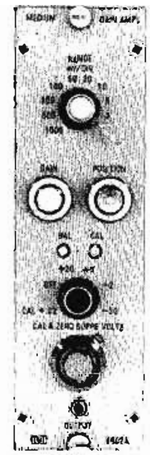
PREAMPLIFIERS

Plug-in signal conditioners for recording

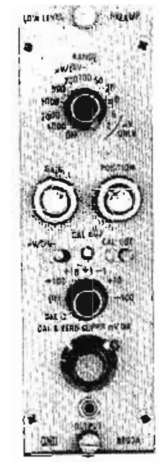
Models 8801A, 8802A, 8803A



8801A
5 mV/div



8802A
1 mV/div



8803A
1 μV/div

DC Coupled Preamplifiers

The three dc-coupled preamplifiers on this page are the primary general-purpose devices used to couple external signals to the recorder. Each unit features a front-panel range switch and lockable gain vernier and zero position controls. Positive and negative zero offset is standard in all three units, with switchable ranges and a lockable, 10-turn potentiometer with calibrated dial face. A switch-selected, internal ±1% calibrator allows a quick check of system accuracy, and front-panel screwdriver-set calibration controls are available in all three units. Front-Panel dc balance controls are provided on the 8801A and 8802A, but are not needed on the 8803A because of the floating and guarded input circuit. Each unit features an output phone jack for the monitoring of the input signal by other devices without additional signal loading, or when the preamplifier is used separately from the recorder as a bench-top unit (Option 001 is the case and power supply for separate use, and includes the 440 Hz photochopper supply when ordered with the 8803A). All units may be operated directly from the output of Hewlett-Packard linear velocity and linear displacement transducers, or with other transducers utilizing dc excitation.

Specifications, Model 8801A

Input ranges: 5, 10, 20, 50, 100, 200 mV/div; 0.5, 1, 2, 5 V/div. Accuracy ±1%.

Type of input: balanced to ground; 500 kΩ ±1% in parallel with approx 100 pF each side.

Common mode rejection: 48 dB min, dc to 140 Hz; ±50 V max on 5, 10, 20 mV/div ranges; ±500 V max all other ranges.

Frequency response and rise time: see chart on page 225.

Zero suppression: 0 to ±10 and ±100 V for single-ended or differential signals (±50 V max on 5, 10, 20 mV/div ranges); calibrated 10-turn potentiometer with ±0.1% resolution; accuracy ±0.5% of suppression range, ±1% of reading.

Calibration: internal, +100 mV ±1%.

Price: Model 8801A $350

Option: 001 bench-top unit with power supply and portable case add $415

Specifications, Model 8802A

Input ranges: 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000 mV/div; accuracy ±1%.

Type of input: balanced to ground; 180 kΩ ±1% in parallel with approx 100 pF each side.

Common mode rejection: 48 dB min, dc to 60 Hz on 1000 mV/div range, dc to 150 Hz all other ranges; ±12.5 V max on 1, 2, 5 mV/div ranges; ±125 V max on 10, 20, 50 mV/div ranges; ±500 V max all other ranges.

Frequency response and rise time: see chart on page 225.

Zero suppression: 0 to ±2 and ±20 V for single-ended or differential signals (±12.5 V max on 1, 2, 5 mV/div ranges); calibrated 10-turn potentiometer with ±0.1% resolution; accuracy ±0.5% of suppression range, ±1% of reading.

Calibration: internal, +20 mV ±1%.

Price: Model 8802A $325

Option: 001 bench-top unit with power supply and portable case add $415

Specifications, Model 8803A

Input ranges: 1 to 5000 μV/div and 10 to 5000 mV/div, 21 ranges in a 1, 2, 5 sequence. Accuracy ±2%.

Type of input: floating and guarded signal pair; 1 MΩ on mV ranges.

Common mode rejection (dc): 160 dB min on μV ranges, 100 dB min on mV ranges: 1 kΩ max source unbalance; ±300 V max.

Common mode rejection (ac): 120 dB min on μV ranges, 60 dB on mV ranges at 60 Hz; 500 kΩ max source unbalance; ±10 V max, 1 μV/div; ±20 V max, 2 μV/div; ±50 V max, 5 μV/div, 100 V max, 10 μV/div and 10 mV/div; ±220 V max all other ranges.

Frequency response and rise time: see chart on page 225.

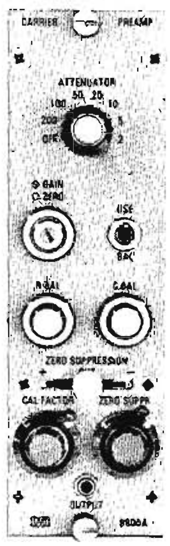
Zero suppression: μV ranges: 0 to ±1, 10, 100 mV; mV ranges: 0 to ±1, 10, 100 V; calibrated 10-turn potentiometer with ±0.1% resolution, accuracy ±1% of suppression range.

Calibration: internal, +200 μV ±1% on μV range, +200 mV ±1% on mV range.

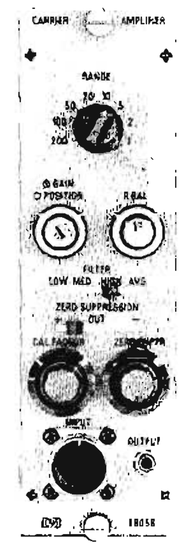
Price: Model 8803A $695

Option: 001 bench-top unit with power supply and portable case add $505

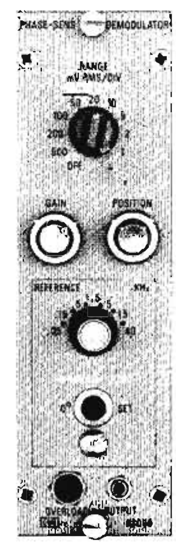
PREAMPLIFIERS
Plug-in signal conditioners for recording
Models 8805A, 8805B, 8806B



8805A



8805B



8806B

8805A, 8805B Carrier Preamplifiers

The carrier preamplifiers measure physical variables that can be coupled to suitable carrier excited transducers, such as strain gauge bridges, differential transformers, and resistance or reactance transducers. An internal oscillator provides an excitation voltage for the external transducer, eliminating the need for external excitation circuitry. A cal factor control allows attenuation and zero suppression to be calibrated in transducer load units. An internal switch is provided for full or half bridge use. The 8805B adds automatic quadrature signal balance, signal averaging capability, and selectable internal calibration for 2% to 100% of full scale.

Specifications, Models 8805A, 8805B

Sensitivity: 10 μV/div.
Input attenuator: X1, 2, 5, 10, 20, 50, 100, 200; accuracy ±2%.
Input impedance
 8805A: approx 10 kΩ.
 8805B: 1 MΩ ±10%, single ended.
Transducer impedance: transducer load impedance connected to excitation terminals 100 ohms min; transducer impedance connected to signal input terminals 5 kΩ max.
Excitation: floating source 5 V nominal, 2400 Hz ±2%; internal full bridge/half bridge switch grounds C.T. of excitation for use with half-bridge transducers.
Quadrature rejection: greater than 40 dB; quadrature signal less than 50 div; C bal control permits bucking of transducer quad unbalance up to ±5 mV/V.
Zero suppression: 0 to 100% of transducer full load rating, for transducer cal factor up to 10 mV/V at full load; calibrated 10-turn potentiometer with 0.1% resolution; accuracy ±0.5% of suppression range; R bal control permits bucking of inphase unbalance to ±3 mV/V regardless of cal factor.
Frequency response: dc to 110 Hz (—3 dB @ 10 div).
Rise time: approx 5 ms.
Calibration
 8805A: 2% ±0.02% of transducer full scale output.
 8805B: switchable, 2%, 10%, 50%, 100% ±1% of full scale.

Prices

Model 8805A	$425
Model 8805B	$675
Option: 001 (either model) bench-top unit with power supply and portable case	add $485

8806B Phase Sensitive Demodulator

The 8806B provides a dc output proportional to the rms value of the input signal that is in phase or 180° out of phase with respect to a reference voltage. Plug-in modules provide various combinations of reference frequency ranges and phase shift capability.

Specifications, Model 8806B

Input ranges: 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500 mV rms/div; reference voltage 3-133 V rms in two overlapping ranges, internal range switch.
Type of input: signal input: transformer isolated, floating and guarded, approx 1 MΩ; reference input: differential, transformer coupled, approx 500 kΩ each side to ground.
Common mode rejection: 40 dB min to 10 Hz, 500 V rms max; quadrature tolerance 50 div max.
Reference frequency range: 50 Hz to 40 kHz in six bands with variable frequency plug-in; fixed frequency calibrated plug-ins 60 Hz, 400 Hz, 5 kHz.
Frequency response and rise time
 Ref frequency: 60 Hz: 12 Hz, 50 ms; 400 Hz: 65 Hz, 9 ms; 5 kHz: same as 8801A (see chart on page 225).
Phase shifter (plug-in)
 Fixed frequency: 0°-90° dial; 2° graduations in four quadrants; accuracy ±3%.
 Variable frequency: continuous 0-360°.
Calibration: internal, 1 V rms at carrier ref frequency.

Price: Model 8806B — $550

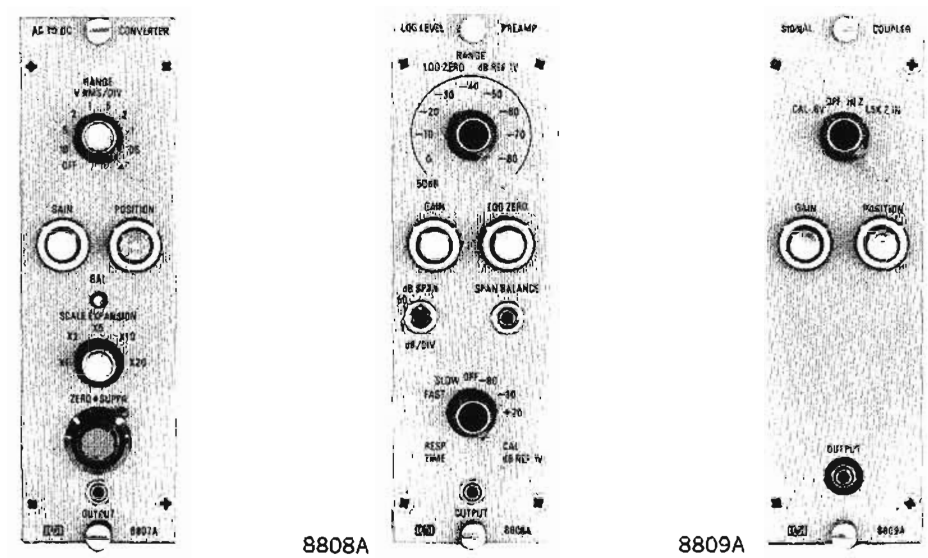
Options

001	bench-top unit with power supply and portable case	add $415
002	variable frequency phase shifter plug-in, 50 Hz to 40 kHz	$200
003	calibrated phase shifter plug-in, 60 Hz	$150
004	calibrated phase shifter plug-in, 400 Hz	$150
005	calibrated phase shifter plug-in, 5 kHz	$150

PREAMPLIFIERS

Plug-in signal conditioners for recording

Models 8807A, 8808A, 8809A



8807A 8808A 8809A

8807A AC-DC Converter

The 8807A provides a dc voltage output proportional to the average value of a full wave rectified ac input signal. Range sensitivity is calibrated in terms of rms for sinusoidal waveforms. The input circuit is transformer coupled, floating and guarded for high common mode rejection. Calibrated full-range zero suppression and variable scale expansion permit analysis of small excursions in large input signals. Option 001 extends the low frequency limit from 330 Hz to 50 Hz at the sacrifice of envelope rise time.

Specifications, Model 8807A

Input ranges: 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, V rms/div; accuracy ±2%; scale expansion: X1, 2, 5, 10, 20 ±2%.

Type of input: floating and guarded signal pair; approx 1 MΩ shunted by 10 pF and stray cable capacitance.

Input frequency range: standard model, 330 Hz to 100 kHz; Option 001, 50 Hz to 100 kHz.

Common mode rejection: 60 dB min at 60 Hz, 40 dB min at 400 Hz, with up to 10 kΩ source unbalance; ±500 V max.

Zero suppression: 0 to 100% of full scale, any range; calibrated 10-turn potentiometer.

Frequency response and rise time

Standard model: 54 Hz, 11 ms.

Option 001: 9 Hz, 70 ms.

Calibration: internal, 1 V ±1%; approx 500 Hz.

Price: Model 8807A — $775

Options

001	50 Hz to 100 kHz signal filter	N/C
002	dc plug-in	N/C
003	bench-top unit with power supply and portable case	add $415

8808A Logarithmic Preamplifier

The 8808A is an average detecting logarithmic converter. It is calibrated in decibles, where zero dB is taken as 1 V rms at the input. The unit can operate over a 50 dB or 100 dB span allowing signals from 100 μV to 1 V rms to be recorded without changing ranges.

Specifications, Model 8808A

Sensitivity ranges

50 dB span: bottom scale −80 to 0 dB below 1 V in 10 dB steps.

100 dB span: −80 to −50 dB below 1 V in 10 db steps.

Type of input: single ended, 1 MΩ min.

Input frequency range: 5 Hz to 100 kHz slow response range; 500 Hz to 100 kHz fast range.

Rise time 10% to 90% (10 div): fast response, 20.5 ms (875 dB/s); slow response 2 s (9 dB/s).

Calibration: internal at approx 500 Hz: −80, −30, +20 dB referred to 1 V; accuracy of −30 dB position ±0.25 dB.

Price: Model 8808A — $625

Option: 001 bench-top unit with power supply and portable case — add $415

8809A Signal Coupler

The 8809A inexpensively connects an external signal for recording. Available are front-panel output, lockable zero and gain controls, and switchable galvanometer (1.5 kΩ) or Hi Z (>100 k) input impedance.

Specifications, Model 8809A

Input range: adjustable from 20 to 50 mV/div.

Type of input: switch selected, 1.5 kΩ ±2% or 100 kΩ min, single ended.

Frequency response and rise time: same as 8801A (see chart on page 225).

Calibration: internal, 600 mV ±2%.

Price: Model 8809A — $125

Option: 001 bench-top unit with power supply and portable case — add $415

Graphic recorders

Chart recorder supplies

The following supplies are those most frequently used in recording applications. A complete list of available supplies may be obtained by contacting your local Hewlett-Packard sales and service office.

X-Y recorder supplies

Graph Paper, 8½ in. x 11 in. (21.6 cm x 28 cm)

Type	Plot Area	Weight	Part Number 100-Sheet Box	Price
English	7 in. x 10 in.	light	9270-1007	$3.50
		heavy	9270-1006	$3.00
Metric	18 cm x 25 cm	light	9270-1027	$3.75
		heavy	9270-1023	$4.00

Graph Paper, 11 in. x 16½ in. (28 cm x 41.9 cm)

Type	Plot Area	Weight	Part Number 100-Sheet Box	Price
English	10 in. x 15 in.	light	9270-1005	$4.50
		heavy	9270-1004	$4.50
Metric	25 cm x 38 cm	light	9270-1042	$4.50
		heavy	9270-1024	$4.50

Disposable Pens (one pen recorders)

Color	Part Number (package of 3)	Price
Red	5081-1190	$4.50
Blue	5081-1191	$4.50
Green	5081-1192	$4.50
Black	5081-1193	$4.50

Disposable Pens (two pen recorder—7046A)

Color	Part Number (package of 3)	Price
Red	5060-6662	$4.50
Blue	5060-6664	$4.50
Black	5060-6668	$4.50

Strip chart recorder supplies

Chart Paper, 5-inch (680, 7143A/B)

Type	Description	Part Number	Price
Ink Writing			
English	5 in. x 95 ft	9270-1012	$2.10
Metric	12 cm x 28.5 m	9270-1025	$2.50
Electric Writing			
English	5 in. x 65 ft	9280-0136	$4.90
Metric	12 cm x 19.5 m	9270-1081	$4.90

Chart Paper, 10-inch (7100B, 7101B, 7127A, 7128A)

Type	Description	Part Number	Price
Ink Writing			
English	10 in. x 120 ft	9270-1010	$3.25
Metric	25 cm x 36 m	9270-1037	$3.25
Electric Writing			
English	10 in. x 100 ft	9270-1078	$7.90
Metric	25 cm x 30 m	9270-1082	$7.90

Chart Paper, 10-inch (7123A/B)

Type	Description	Part Number	Price
Ink Writing			
English	10 in. x 95 ft	9280-0175	$3.25
Metric	25 cm x 28.5 m	9280-0176	$3.25
Electric Writing			
English	10 in. x 55 ft	9280-0177	$7.00
Metric	25 cm x 16.5 m	9280-0178	$7.00

Chart Paper, 10-inch (7130A)

Type	Description	Part Number	Price
Ink Writing			
English	10 in. x 100 ft	9280-0264	$3.25
Metric	25 cm x 30 m	9280-0265	$3.25

Recording Ink, 3 cc Cartridge (680, 7100B, 7101B, 7120A, 7128A)

Color	Part Number	Price
Red	1530-1024	$ .50
Green	1530-1025	$ .50
Black	1530-0705	$ .50
Blue	1530-1034	$ .50
Purple	1530-0984	$ .50

Recording Ink, 5 cc Cartridge (7123A/B, 7130A, 7143A/B)

Color	Part Number	Price
Blue	07143-61701	$1.50
Red	07143-61700	$1.50
Black	07143-61702	$1.50

Oscillographic recorder supplies

Chart Paper

Recorder System	Description	Part Number	Price
7402A	2 x 50 mm, 275 ft (84 m) roll	9280-0258	$ 5.00
	1 x 100 mm, 275 ft (84 m) roll	9280-0276	$ 5.00
7414A	4 x 40 mm	9270-0878	$25.00
7702B	2 x 50 mm, 200 ft (96 m) roll	651-52	$12.50
7706B/7727A	6 x 50 mm	651-57	$21.80
7708B/7729A	8 x 40 mm	651-58	$23.80
7731A	16 x 20 mm	651-201	$24.65
7858B/7878A	8 x 40 mm, Z-Fold pack	9280-0067	$27.50
	8 x 40 mm, 500 ft (154 m) roll	9280-0066	$35.00

Recording Ink, Cartridge

Recorder System	Description	Part Number	Price
7402A	Blue-black, 55 cc	07402-60008	$9.50
7858B/7878A	Blue, 4 oz	5081-1188	$3.00

PORTABLE TAPE RECORDER
Laboratory Performance and Accuracy
3960 Series

3960A

The HP Model 3960 is a portable and rugged, 4-track, 3-speed, instrumentation magnetic tape recorder.

The tape transport assembly includes the capstan motor and two reel motors, record and reproduce heads, tape guides and tension arms, power supply, preamplifiers, meter system, and the controls. Plug-in solid-state circuit boards contain the necessary circuitry for FM Record/Reproduce, for Direct Record/Reproduce, and for an accessory Voice Channel.

All tape drive components are mounted on a solid casting. The tape guides and the record and reproduce heads mount directly on the capstan bearing support, assuring permanent alignment.

Input and output connectors are located on the control panel. A single system connector on the rear panel also provides input/output connections.

Standard Speeds (ips)	Channel Configuration				
	4 FM	2 FM 2 Dir	3 FM 1 Dir	1 FM 3 Dir	4 Dir
15, 3¾, 15/16	3960A	3960B	3960E	3960F	3960G
15, 3, 1.5	3960D	3960C	3960H	3960J	3960K

Note: Bias oscillator included in systems equipped with Direct electronics.

Specifications

Tape transport

Heads: 4-track Record and 4-track Reproduce.

Tape speeds: three electrically selected with 3-position speed selector on front panel. Any 3 octal speeds of 15, 7½, 3¾, 1⅞, or 15/16 ips or the decade speeds of 15, 3, and 1.5 ips may be optionally selected.

Tape speed accuracy: ±0.2%.

Operating modes: Forward and Reverse Record, Forward and Reverse Play, Fast Forward, Fast Rewind, Stop. Pushbutton selected.

Start and stop times (typical):

Tape Speed: (ips)	15	3-3/4	15/16
Start (Seconds)	2.0	0.9	0.25
Stop: (Seconds)	0.25	0.25	0.25

Rewind time (typical): 1800-ft reel in 80 seconds; 2300-ft reel in 130 seconds.

Braking: mechanical differential brakes, solenoid actuated. Brakes apply if power fails.

End-of-tape sensing: tape drive is stopped by tension arms retracting at end of tape.

Reel revolution counter: 4-digit revolution counter with push-button reset.

Flutter: measured in accordance with latest IRIG Standards.

Tape Speed (ips)	Passband (Hz)	Flutter (% p-p)
15	0.2 - 2500	0.35
7½	0.2 - 1250	0.35
3¾	0.2 - 625	0.40
3	0.2 - 500	0.45
1⅞	0.2 - 312	0.50
1.5	0.2 - 250	0.55
15/16	0.2 - 156	0.70

Direct electronics

Passband and Signal-to-noise

Tape Speed (ips)	Passband (±3 dB)	Signal/Noise Ratio (dB)
15	70 Hz - 60 kHz	38
7½	50 Hz - 30 kHz	38
3¾	50 Hz - 15 kHz	38
3	50 Hz - 12 kHz	38
1⅞	50 Hz - 7.5 kHz	38
1.5	50 Hz - 6 kHz	38
15/16	50 Hz - 3.75 kHz	38

Input level: 0.1 volt rms to 10 volts rms.

Input impedance: 50 k ohms, or greater, shunted by 200 pF maximum, single-ended.

Output level: 0 to 5 volts peak-to-peak (adjustable).

Output impedance: 140 ohms maximum, single-ended.

FM electronics

Passband and Signals-to-noise Ratio

Tape Speed (ips)	Carrier Center Frequency (kHz)	Passband (kHz)	S/N Ratio (dB)
15	27	0 to 5	48
7½	13.5	0 to 2.5	48
3¾	6.75	0 to 1.25	48
3	5.40	0 to 1	48
1⅞	3.38	0 to 0.625	48
1.5	2.70	0 to 0.5	47
15/16	1.69	0 to 0.312	46

Flutter compensation: standard on all models. Can be switched on and off with slide switch behind front access door. Flutter compensation is permanently wired with Channel 2 as the reference.

Distortion: less than 1.5% at 15 through 1⅞ ips; 2% at 1.5 and 15/16 ips.

Linearity: ±1% of p-p output for best straight line through zero.

DC drift: ±0.1% of peak-to-peak output per degree Centigrade (Record-Reproduce).

Input level: 1 volt peak-to-peak to 30 volts peak-to-peak.

Input impedance: 50 k ohms, or greater, shunted by 200 pF maximum, single-ended.

Output level: 0 to 5 volts peak-to-peak (adjustable).

Output impedance: 140 ohms maximum, single-ended.

Crystal reference: FM Center Frequencies for Reproduce calibration. Crystal accuracy is 100 parts per million (0.01%) over specified environmental conditions.

DC calibration voltages: rotary switch selects ±10, ±5, ±2.5, or ±1.414 V dc. Accuracy ±2%.

"E-to-E" mode: Electronics-to-Electronics mode enables input signal to be automatically transferred (bypassing heads) to output during Fast Forward, Rewind, or Stop.

Signal monitoring

Peak reading meter: in Record, meter reads in percentage of full deviation (40%) or drive level on tape. In Reproduce, meter reads output voltage.

Meter modes: meter has two modes: In PEAK mode it reads peak of absolute value, including any dc components. In DC mode it reads dc component of signal.

Meter accuracy: better than ±½ dB for signals with 50 to 100% duty cycle; better than ±1 dB for 1 to 50% duty cycle.

Power requirements: 115-230 Vac ±10%, 48-440 Hz. Consumption 80 watts. Also operates on 12 or 28 Vdc using accessory DC/AC Inverter (Model 13061A or 13061B).

Environment

Temperature: operating 0° to +55°C, +10° to +40°C meeting all specs (tape limited). Non operating: −40° to +75°C.

Altitude: operating: 15,000 feet; Nonoperating: 25,000 feet.

Humidity: 10% to 95% (+25° to +40°C), noncondensing.

Shock: 30g maximum (11 ms) nonoperating.

Physical characteristics

Mounting: supplied with portable case. Rack mounting kits available for standard 19-inch equipment racks and for HP Series 2940A Cabinets.

Size: 16¾" wide, 15" high, 7⅜" deep (425 x 381 x 187 mm).

Weight: 50 pounds (22.7 kg).

Typical models/prices

3960A: 4 Channels FM with 15, 3¾, 15/16 ips — $4585.00

3960G: 4 Channels Direct with 15, 3¾, 15/16 ips — $4270.00

Accessories furnished

1. Operation and Service Manual.
2. Male System Connector.
3. Extender Board.
4. Two Jumper Cables (for FM Calibration).
5. Four Locking Knobs for RECORD LEVEL controls.
6. One empty 7-inch plastic reel.
7. One 7-inch reel containing 2300 feet of ¼-inch 1-mil instrumentation tape.
8. One fuse for 230 Vac operation.
9. One Tuning Tool.
10. One BNC-BNC Test Cable.

Accessories available

(field and factory installed)

Accessory Kit, Model 13070A — $ 31.50
(One kit included at no charge with each 3960 Series Recorder.)

Remote Start/Stop Switch, HP Model 13060A — $ 40.00
Includes 8-foot cable and mating connector.

Inverter (12 Vdc to 115 Vac), HP Model 13061A — $190.00

Inverter (28 Vdc to 115 Vac), HP Model 13061B — $190.00
Plug-in unit for battery operation. Includes power input cable, fuses, and mating connector.

Tape Loop Adapter, HP Model 13062A — $370.00
Holds a tape loop of from 5 to 30 feet.

Voice Channel, HP Model 13063A — $190.00
Voice record and reproduce amplifier card for all tape speeds. Includes microphone.

Rack Mount Kit, HP Model 13065A — $ 21.00
For stationary flush-mounting a 3960 in 19-inch racks..

Fiberglass Transit Case, HP Model 13066A — $375.00
Moisture and dust proof. Protects against excessive transportation shock and vibration.

Rack Slide Mounting Kit, HP Model 13068A/B — $165.00
For flush-mounting the 3960 in cabinets and racks. Allows 3960 to be pulled away from rack and rotated 90° for easy access to adjustments and replaceable parts. Model 13068A is for standard 19-inch racks; Model 13068B is the HP Series 2940 and 1073 cabinets.

Options available

(Must be installed at factory during manufacturing)

Remote Control Option — $380.00
Allows electronic switching of all modes except tape speed and power on-off. Control lines select all other recorder functions with a momentary-contact closure. Status lines indicate the appropriate recorder condition.

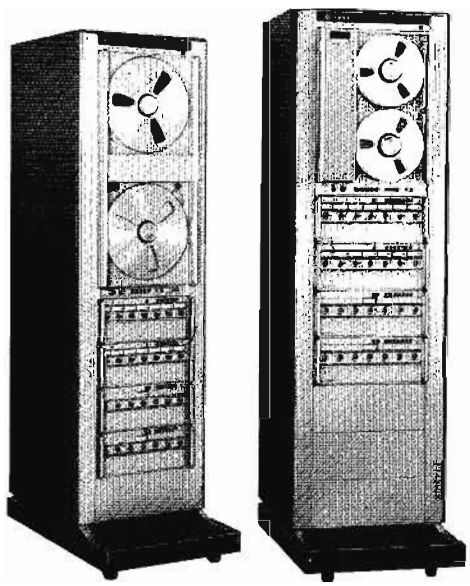
Tape Speed Servo Option — $350.00
Provides the capability of controlling tape speed from a reference signal recorded on any of the four tracks. Minimum time base error is ±4 μsec at 15 ips and ±25 μsec at 15/16 ips. The control panel includes a switch for changing from tachometer mode to tape servo mode, and two indicator lights to indicate the mode in use.

INSTRUMENTATION RECORDERS

Intermediate and Wide-Band Systems

3950 and 3955 Series

IRIG-compatible wide-band and intermediate band instrumentation recorders



3950 3955

The HP 3955 and 3950 Series Magnetic Tape Recorders provide highly flexible, yet easy-to-operate systems to record and/or reproduce electrical signals. Both 7- and 14-channel capacity is available; plug-in electronics (Direct and FM) can be intermixed as desired. Maximum bandwidth of the 3955 at 60 ips is 300 kHz for Direct recording. Maximum bandwidth of the 3950 at 120 ips is 1.5 MHz for standard unit and 2.0 MHz for 3950 Option 011.

Each 3955/3950 System includes a high performance tape transport and a number of interchangeable record and reproduce amplifiers, offering an extremely wide latitude in determining the exact system configuration. Seven or fourteen track capability in either of two basic tape transports is available.

Monitoring meters, channel-select switches, and test-signal connectors on the record and reproduce mainframes allow the monitoring of a test signal on any desired channel as well as the normal input and output signals.

All tape-drive controls for the system are located on the transport chassis. Pushbuttons are utilized throughout to obtain the desired mode of operation. Rear connections are provided for remote-control operation, accessories, and interconnecting cabling.

The smaller transport, which can handle tape reels up to 10½" in diameter, provides economy as well as performance. This transport is for applications requiring average recording times.

The larger transport accepts tape reels up to 15" in diameter to provide over 19 hours of recording time at a tape speed of 1⅞ ips.

Specifications

Tape Transport

Tape speed accuracy: standard ±0.25% of nominal speed selected, using line power of 117 V ac ±10%, 60 Hz ±0.03%. With ac power supply (HP Model 3680A): ±0.25% of nominal speed selected, using line power of 117 V ac ±10%, with 47 to 63 Hz line frequency variations.

Absolute time base accuracy: with tape speed servo; absolute accuracy of reproduce data time base will be within ±0.01% of recorded data time base when using 200 kHz at 120 ips constant-amplitude reference (HP Model 3681A), and within ±0.02% of recorded data time base when using 17 kHz modulated with 60 Hz reference. (HP Model 3681A Option 001).

Start time: at nominal speed in approximately 6 seconds. Flutter will be within specifications in approximately 10 seconds at 60 and 120 ips and proportionally less time at lower tape speeds.

Stop time: less than 5 seconds from a manually operated "stop" command, end-of-tape, or power failure.

Rewind time: less than 4 minutes for 9200 feet of tape.

Braking: mechanical differential brakes which provide power *fail-safe* operation when engaged from any mode of operation or by power failure.

Flutter: measured in accordance with the latest IRIG standards:

0.035% p-p from 0.2 Hz to 10 kHz @ 120 ips (3950 Systems)

0.030% p-p from 0.2 Hz to 10 kHz @ 60 ips (3955 Systems)

Jitter: random jitter in the reproduce signal between any two events will be typically within the following 3-sigma (99.7%) peak-to-peak limits:

120 ips 0.3 μs @ 0.1 ms, and 1.5 μs @ 1.0 ms

60 ips 0.4 μs @ 0.1 ms, and 2.0 μs @ 1.0 ms

Interchannel time displacement error (ITDE): dynamic ITDE will be less than ±0.5 μsec at 120 ips or ±1.0 μsec @ 60 ips between any two adjustment tracks on the same head stack.

Tape breakage sensor: *tape breakage or end-of-tape,* sensed by take-up reel tension-sensing arm, will stop tape drive.

Remote control: connector (mating connector supplied) on rear of tape transport assembly permits remote control of all transport operating controls.

Heads: the head assembly complies with latest IRIG standards including mechanical geometry, track numbering, azimuth, and polarity. Seven data tracks on ½-inch tape; 14 data tracks on 1-inch tape. An edge track is available on 3955A/B/C/D systems for voice annotation.

Direct Electronics

Passband, Signal-to-Noise Ratio, and Risetime:

Intermediate Band

Tape Speed (ips)	Passband (±3 dB)	S/N Ratio (dB)
60	300 Hz - 300 kHz	40
30	150 Hz - 150 kHz	40
15	100 Hz - 75 kHz	40
7½	100 Hz - 38 kHz	40
3¾	100 Hz - 19 kHz	40
1⅞	100 Hz - 9.4 kHz	40

1.5 MHz Wideband

Tape Speed (ips)	Passband* (±3 dB)	S/N Ratio (dB)	Maximum Rise Time (μsec)
120	400 Hz - 1.5 MHz	30	0.4
60	400 Hz - 750 kHz	29	0.8
30	400 Hz - 375 kHz	29	1.6
15	400 Hz - 187 kHz	28	3.2
7½	400 Hz - 94 kHz	27	6.4
3¾	400 Hz - 47 kHz	26	12.8
1⅞	400 Hz - 24 kHz	24	25.6

2.0 MHz Wideband

Tape Speed (ips)	Passband* (±3 dB)	S/N Ratio (dB)	Maximum Rise Time (μsec)
120	500 Hz - 2 MHz	22	0.3
60	500 Hz - 1 MHz	24	0.6
30	500 Hz - 500 kHz	25	1.2
15	500 Hz - 250 kHz	26	2.4
7½	500 Hz - 125 kHz	26	4.8
3¾	500 Hz - 62 kHz	26	9.6

*Measured in accordance with IRIG Standards.

Envelope Delay

1.5 MHz Systems

Tape Speed (ips)	Measurement Bandwidth	Delay*
120	100 kHz - 1.5 MHz	500 ns p-p
60	100 kHz - 750 kHz	1000 ns p-p
30	100 kHz - 375 kHz	2000 ns p-p

2.0 MHz Systems

Tape Speed (ips)	Measurement Bandwidth	Delay*
120	100 kHz - 2 MHz	500 ns p-p
60	100 kHz - 1 MHz	1000 ns p-p
30	100 kHz - 500 kHz	2000 ns p-p

*Measured in accordance with IRIG Standards.

Input/Output Levels and Input/Output Impedances:

Specification	300 kHz Intermediate Band	1.5 MHz Wideband	2.0 MHz Wideband
Input Level (adjustable)	0.25 V rms to 10.0 V rms		
Input Impedance (unbalanced-to-ground)	1 kilohm shunted by 100 pF	1 kilohm shunted by 70 pF	
Output Level (adjustable)	1.0 V rms into 100 ohms	1.0 V rms into 75 ohms	0.5 V rms into 75 ohms
Output Impedance (single-ended)	50 ohms ±20%	75 ohms ±20%	

FM Electronics

Passband, Signal-to-Noise Ratio, and Rise Time:

Low Band (±40% Deviation)

Tape Speed (ips)	Carrier Center Frequency (kHz)	Passband (kHz) (+0.5, −1.0 dB)	S/N Ratio (dB)
120	108	DC-20	50
60	54	DC-10	50
30	27	DC-5	48
15	13.5	DC-2.5	46
7½	6.75	DC-1.25	45
3¾	3.38	DC-0.625	44
1⅞	1.69	DC-0.312	42

Intermediate Band (±40% Deviation)

Tape Speed (ips)	Carrier Center Frequency (kHz)	Passband (kHz) (+0.5, −1.0 dB)	S/N Ratio (dB)
120	216	DC-40	48
60	108	DC-20	48
30	54	DC-10	46
15	27	DC-5	44
7½	13.5	DC-2.5	43
3¾	6.75	DC-1.25	42
1⅞	3.38	DC-0.625	41

Wideband Group I (±40% Deviation)

Tape Speed (ips)	Carrier Center Frequency (kHz)	Passband (kHz) (+0.5, −1.0 dB)	S/N Ratio (dB)
120	432	DC-80	47
60	216	DC-40	47
30	108	DC-20	46
15	54	DC-10	43
7½	27	DC-5	43
3¾	13.5	DC-2.5	42
1⅞	6.75	DC-1.25	40

Wideband Group II (±33% Deviation)

Tape Speed (ips)	Carrier Center Frequency (kHz)	Passband (kHz) (+1, −3 dB)	S/N Ratio (dB)	Rise Time (μsec)
120	900	400	36	1.25
60	450	200	36	2.5
30	225	100	35	5
15	112.50	50	35	10
7½	56.25	25	33	20
3¾	28.12	12.5	33	40
1⅞	14.06	6.25	30	80

Linearity, Input/Output Levels, Input/Output Impedances:

Specification	Low, Intermediate, and Wideband Group I	Low, Intermediate, Wideband Group I, and Wideband Group II
Linearity*	±0.5%	±0.2%
Input Level** (adjustable)	1.4 V p-p (0.5 V rms) to 30 V p-p (10 V rms)	0.7 V p-p (0.25 V rms) to 24 V p-p (8.5 V rms)
Input Impedance (unbalanced-to-ground)	20 kilohms shunted by 150 pF	1 kilohm shunted by 200 pF
Output Level** (adjustable)	0 to 2.8 V p-p (1 V rms) into 600 ohms	0 to 2.8 V p-p (1 V rms) into 75 ohms
Output Impedance (unbalanced-to-ground)	600 ohms ±20%	75 ohms ±10%

*Referenced to best straight line.
**The frequency deviation and the output signal may be switched to either proportional-to, or inversely-proportional-to signal input, allowing compatibility with both IRIG and non-IRIG systems.

Total Harmonic Distortion:

Low Bands	<1.5%
Intermediate Bands	<2.0%
Wideband Group I	<2.5%
Wideband Group II	<2.5%

System power requirements

Voltage: 115 Vac ±10% (230 Vac optional).

Frequency: Nominal 60 Hz line (50 Hz optional). Refer to Tape Speed Accuracy and Absolute Time Base Accuracy specifications.

Power Consumption (Typical Systems):
- **3950A System:** 700 watts
- **3950B System:** 600 watts
- **3955A System:** 700 watts
- **3955B System:** 600 watts
- **3955C System:** 450 watts
- **3955D System:** 350 watts

Environment

Temperature: Operating: +32° to 131°F (0° to 55°C) excluding tape limitations; +50° to +104°F (+10° to 40°C) meeting all specifications.
Nonoperating: −40° to +167°F (−40° to +75°C).

Altitude: Operating: to 15,000 feet (4,572 m).
Nonoperating: to 40,000 feet (12,192 m).

Relative Humidity: Will operate from 10% to 90% without condensation, excluding tape limitations.

Physical characteristics

Complete system: Size and weight are for a system mounted in a Model 1073C Cabinet. Other cabinets and cases optionally available.

Height: 78¼ inches (1990 mm) including casters.

Width: 21 inches (533 mm).

Depth: 37¾ inches (960 mm) including front base extension.

Weight: 635 lb (288 kg) for typical 14-channel system. Shipping weight is 860 lb (390 kg).

Typical systems

Analog Laboratory Instrumentation Tape Recorder Systems				
7 Channels (½" tape)	**14 Channels (1" tape)**	**Direct Passband (at highest speed)**	**Reel Size**	**Six Tape Speeds**
3950B-011 ($16,455)	3950A-011 ($23,800)	2.0 Wideband (500 Hz - 2.0 MHz)	15" (max)	3¾ to 120 ips
3950B ($14,500)	3950A ($20,950)	1.5 Wideband (400 Hz - 1.5 MHz)		
3955B ($10,650)	3955A ($15,250)	300 kHz Intermediate Band	15" (max)	1⅞ to 60 ips
3955D ($10,200)	3955C ($14,700)		10½" (max)	
Typical system prices are for 7-channel or 14-channel direct record/reproduce systems equalized for one reproduce speed.				

Accessories furnished with each system:

A. One Operating and Service Manual.

B. All necessary mating connectors and cables except BNC input and output.

C. Filler panels. (If cabinet is included with system.)

D. Accessory Kit: Includes cotton-tipped swabs, alignment wand, and two amplifier extracting tools.

E. One empty precision reel, 10½ or 14-inch depending on system.

F. Tape: One-mil instrumentation tape of either ½ or 1 inch (used for final system testing before shipment) on precision reel.

Accessories available:

Automatic Tape Degausser, HP Model 3603A $1090

Degausses magnetic tape to 90 dB below saturated recorded level. Automatic operation; complete erasure every time. Designed for continuous operation. Accepts 3" to 15" diameter reels; ¼" to 1"-wide tape. Use in rack or on table top.

Digital Reel Hub Adapter, HP Model 11572. $ 17

Voice Channel, HP Model 3604A $ 570

Records voice commentaries along with data. Provides for edge-track or multiplex recording. Multiplex operation combines voice with data for recording on any direct record channel. Includes loudspeaker and retractable microphone.

AC Power Supply, HP Model 3680A $1150

Used to obtain crystal-controlled drive speed accuracy when system is operated from unstable frequency (47-63 Hz) power source. The Internal Power Amplifier may be driven from either an internal crystal or an external frequency source. Ideal for laboratory or field use, supplying up to 100 watts, 115 volts, at any frequency from 30 Hz to 1.5 kHz.

Tape Servo, HP Model 3681A (constant amplitude) $1450

Generates IRIG-specified speed-control signal for recording on tape with data. When the tape is replayed the reproduced signal is phase compared to either an internal or externally supplied reference. The phase difference is then used to generate the Capstan drive frequency.

Option 01 Amplitude Modulated 17 kHz $1280

Option 02 Constant Amplitude and AM 17 kHz $1650

Remote Control Unit

Includes all functions for tape recorder operations from another location. With 25′ cable. Rack mounting optional.

HP Model 3907-11A (for 10½" real systems) $ 400

HP Model 3907-11A, Option 02 (for 15" reel systems) $ 450

Reproduce Track Selector, HP Model 11539A $ 360

Permits system-economy by using less than a full complement of Reproduce Amplifiers. Each front-panel switch connects any of the 14 recorded data-tracks to the input of a single Reproduce Amplifier. With seven switches available, only one Reproduce Mainframe, and from 1 to 7 Reproduce Amplifiers may be used with a 14-channel system.

Pack Sensor HP Model 11553A $ 370

Senses the remaining tape-pack on both supply and take-up reels. Permits system to be stopped before tape runs off end of reel; used for recycling tape, or turning on a second tape recording before the first one runs out of tape. For 15" reel systems, only.

DIGITAL RECORDER
20 lines/s; quiet; versatile
Model 5050B

Advantages

Inexpensive mixed codes column by column
Versatility of quick-change code discs
few moving parts
Quiet operation
Data storage and digital clock optional

This recorder is compatible with Hewlett-Packard solid state and integrated circuit instruments and a wide variety of other equipment. It prints up to 18 columns of 4 line BCD data from one or two sources up to 20 lines/s.

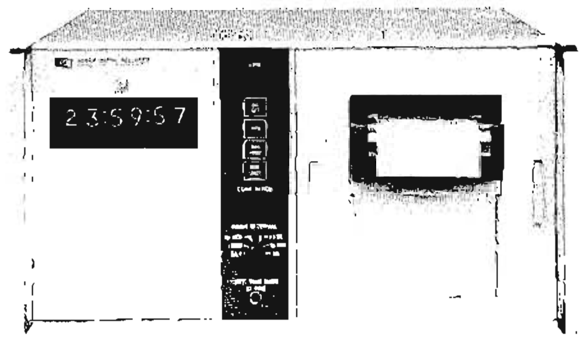
The user can easily change code to 8421+, 8421−, or 4221+ by an inexpensive substitutable code disc, and can change print wheels to have a different code and/or character set in each column. Character suppression allows suppressing a character in each column.

Data storage options reduce data loading time from 50 ms to 0.1 ms and decrease input voltage requirements.

Specifications

Accuracy: identical to input device used.
Printing rate: 20 lines per second, maximum (asynchronous).
Column capacity: to 18 columns.
Print wheels: 16 positions, numerals 0 through 9, −, +, Z, V, Ω, *; other symbols available.
Input requirements—without data storage
Data input: parallel entry, BCD (8421, 4221), "1" state must differ from "0" state by >4.5 V but <75 V.
Input requirements—with data storage options
Data input: parallel entry, BCD, "1" state must differ from "0" state by >1.3 V but <35 V. Input drive ≥100 μA. Data must be on lines when print command occurs and remain until release of hold-off (85 μs after print command).
Transfer time: 50 ms without storage, 0.1 ms with.
Line spacing: adjustable, 3.5 to 4.5 lines/inch.
Inking: ink roller or pressure sensitive paper (use latter where 5050B is idling more than printing, or for temperature extremes).
Conversion: typically takes five minutes.
Operating temperature: −20°C to +55°C with pressure sensitive paper, +10°C to +40°C with ink roller.
Power: 115 or 230 V ±10%, 50 to 60 Hz, approx 100 W idle, 190 W at 20 lines/sec. 50 Hz model with 20 prints/sec available.
Dimensions: cabinet: 16¾" wide, 8½" high, 18⅜" deep (426 x 226 x 467 mm). Rack mount hardware supplied.
Weight: net, 40 lbs (18 kg); shipping, 53 lbs (24 kg).
Price: HP 5050B, $1975. (Plus column boards, see Opt. 20)
Options:
- **001** 8421 "1" state positive code disc, NC
- **002** 8421 "1" state negative code disc, NC
- **003** 4221 "1" state positive code disc, NC

All three code discs are supplied with each 5050B at no charge. However, one of the above options must be specified so 5050B can be delivered with desired disc installed.
- **010** 50 Hz operation, add $15
- **015** Motor control, add $75
- **020** Column boards (one required, in addition to basic instrument, for each two columns to be operated), add $125 each
- **032** Input cable, one per data source, add $60 each
- **035** Input cable, one per IC counter, add $75 each.
- **036** Input cable, to 5323A, add $75 each
- **037** Input cable, to 5360A, add $75 each
- **050** Storage for 20 columns, add $400
- **051** Storage for 10 columns, add $200
- **061** Package for 5360A, add $1490



5050B with Option 055

Option 055 for 5050B recorder

Option 055 Clock, for use with the HP 5050B Digital Recorder, provides a convenient method for recording time while also serving as a programmer for the measuring-recording system. Integrated circuits and transistors perform all timing and logic functions. Column boards required for 5050B operation are built into the clock.

Easy-to-read display tubes indicate time to 23 hours, 59 minutes, 59 seconds. In the printout there is a seventh digit available for indicating tenths of a second. The BCD output code of the clock is selectable to be either +8-4-2-1 or −8-4-2-1, but information is easily adaptable to any other code used on the recorder.

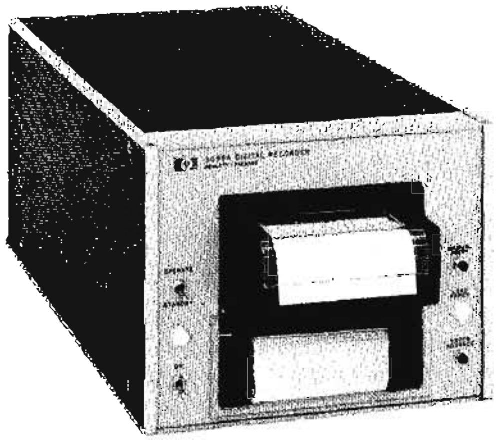
As a programmer, the clock is extremely versatile. Print intervals of 1 second, 10 seconds, 1 minute, 10 minutes, or 1 hour are chosen by a front panel switch. Rates as high as 20 prints per second, determined by an external signal, are acceptable.

The clock is available in kit form for model 5050B or may be installed at the factory in new 5050B Recorders.

Specifications, Option 055

Time base: selectable to be 50 Hz, 60 Hz or external. External requires 10 pps negative pulse.
Print interval:
Internal: selectable to be 1 s, 10 s, 1 min., 10 min., or 1 hour between prints.
External: rates up to 20 prints per second.
Time-of-measurement accuracy: time recorded may be 0.1 s less than correct time ± line accuracy.
Visual indication: 6 in-line digital display tubes indicate to 23 hours, 59 minutes, 59 seconds.
Printed output: seven digits indicate to 23 hours, 59 min, 59.9 s.
BCD output code: +8-4-2-1 or −8-4-2-1 selectable. Output adaptable to other recorder codes.
Print format: time printable in any recorder columns.
Clock set: 4 switches electronically set clock to desired initial time.
Power: 115 V or 230 V ±10%, 50 Hz or 60 Hz.
Weight: net, 3 lbs (1,4 kg).
Price: HP Option 055 (factory installed), $950.
Price of kit for field installation available on request.

DIGITAL RECORDER
10 lines/s with economy and quality
Model 5055A



5055A

Hewlett-Packard Model 5055A Digital Recorder provides a high-performance economical method of making permanent records of digital data. The unit is supplied with complete electronics for 10 columns of input data and will print at rates up to 10 lines per second. It accepts TTL integrated circuit logic levels in either a +8421 or −8421 code, the code being switch selectable on the rear panel.

Quiet, reliable operation is inherent in the design, resulting from the use of very few moving parts. The printer mechanism, manufactured by Hewlett-Packard, is a modified version of a mechanism whose reliability and serviceability has been demonstrated in other Hewlett-Packard recorders for years.

The 5055A prints in ink on regular paper or on pressure sensitive paper. For ink printing, the mechanism includes a continuously rotating ink roller—inherently a more reliable system than a start-stop ribbon mechanism. Paper loading is easy from the front, and when the paper supply runs out, an alarm lamp lights and recording stops automatically. An output signal is provided for inhibiting the data source.

Each column has an individual print wheel which can be changed independently if a different character set is desired in any column. Special wheels can be factory installed at nominal cost or may be field installed at a later date.

The recorder's cabinet is half-rack width and only six inches high. It can be used either on a bench or side by side with another instrument in a rack.

Specifications

Accuracy: identical to input device used.
Print cycle time: 100 ms.
Printing rate: 10 lines/sec maximum, asynchronous.
Print wheels: 16 positions, numerals 0 through 9, +, −, V, A, Ω, *; special wheels available at minimal cost.
Column capacity: supplied complete for 10-column operation.
Electrical
Data input: parallel entry, BCD ±8421 (selected by rear panel switch).
Blanking: Hewlett-Packard counters with blanking will give insignificant zero suppression since blanked digit's output is (1111). May be defeated with rear panel switch.
Logic levels: high state ≥ +2.4 V, +5 V maximum (open input line results in high state); low state ≤ +0.4 V (1.6 mA max., low), 0 V minimum.
Print command: line 1-low to high transition causes print (nominal 1 kΩ input impedance); line 2-high to low transition causes print (nominal 400Ω input impedance). Voltage levels are same as logic levels above, and a minimum pulse width of 0.5 μs is required.
Inhibit voltage: (+) inhibit = transition from (≥0, ≤0.4 V) to (≥2.4 V, ≤5.0 V) upon receipt of print command. Remains at high state until paper advance occurs, approximately 85 ms (<5 mA in low state).
(−) inhibit = inverse of (+) inhibit.
Line spacing: fixed, 4 to 5 lines per inch.
Inking: ink roller or pressure sensitive paper. Pressure sensitive paper is recommended for operation under extreme temperatures.
Accessories furnished: one pad regular paper, one pad pressure sensitive paper, one ink roller, one paper deflector, one power cable.
Operating temperature: 0°C to +50°C with pressure sensitive paper, +10°C to +40°C with ink roller.
Input connector: amphenol 57-40500-375, HP Part No. 1251-0087, 50-pin female. Mating input cable connector: amphenol type 57-30500-375, HP Part No. 1251-0086, 50-pin male.
Front panel controls: power switch, power on indicator light, manual print pushbutton, manual paper advance pushbutton, out-of-paper light, standby/operate switch. (Paper loaded from front.)
Paper requirement: Hewlett-Packard folded tape. Approximately 15,000 lines per pad of regular paper, 18,000 lines per pad of pressure sensitive paper (pad fills 5055A twice and must be divided).
Power: 115 or 230 V ±10%, 60 or 50 Hz (two-speed motor pulley incorporated), approximately 25 W idle, 55 W at 10 lines/sec.
Dimensions: cabinet: 8" wide, 6-3/32" high, 16" deep (203 x 154 x 406 mm).
Weight: net, 18.5 lbs (10 kg) (approximately); shipping, 22 lbs (8.9 kg) (approximately).
Price: $1195.
Accessories available: rack adapter frame 5060-0797, $25.
Option 001: delivered set up for 50 Hz operation. No charge.
Option 002: input cable, 562A-16C. For use with 3450A*, 3480A/B, 5326A/B, 5500A*, 8443A, $60.
Option 003: input cable, 10513A. For use with 5216A*, 5221B*, 5321B*, 5325A/B, 5330A/B, 5331A/B*, 5332A/B*, $75.
Option 004: input cable, 10524A. For use with 5323A, $75.

* Slight modification may be necessary.

Description	Part Number
Ink Roller (Black)	9260-0071
Standard Paper (Single Pad*)	9281-0386***
Standard Paper (Carton of 15 Pads*)	05050-8002***
Pressure Sensitive Paper (Single Pad**)	9281-0387***
Pressure Sensitive Paper (Carton of 15 Pads**)	05050-8003***

* One pad of standard paper is 250 feet long.
** One pad of pressure sensitive paper is 305 feet long.
*** Each pad fills 5055A twice and must be divided.

COUPLER/CONTROLLER
Programmable, bidirectional device interface
Model 2570A

The HP 2570A Coupler/Controller forms the heart of inexpensive, programmable, and expandable systems, providing a bidirectional link that interfaces many Hewlett-Packard instruments (as well as non-Hewlett-Packard instruments) and peripherals to communicate with each other. Because of the many and varied system configurations possible, complete ordering information for coupler/controller systems is contained in a separate form, HP 2019A Systems Ordering Information, available from Hewlett-Packard field sales offices. The Coupler/Controller and its options should be ordered under the 2019A—(list option number here) classification, as shown in parentheses throughout the text, the discussion that follows is essentially a description of the coupler/controller, associated plug-in cards, and some applications. More in-depth literature covering the coupler/controller, as mentioned throughout the following text, is available from Hewlett-Packard.

Operating principles

Operation of the 2570A is based on the concept of providing a common communication code—ASCII (American Standard Code for Information Interchange). The simple system illustrated shows how a device such as a DVM, inputs its data to the coupler/controller which, in turn routes the data to an output device such as a paper tape printer. The sequence of operation is shown in Figure 1. Note that the input data signal is converted from BCD to ASCII on the BCD input card; all data must be in ASCII when it reaches the 2570A backplane. Thus, a single 8-line ASCII bus on the backplane handles all data transfer between devices.

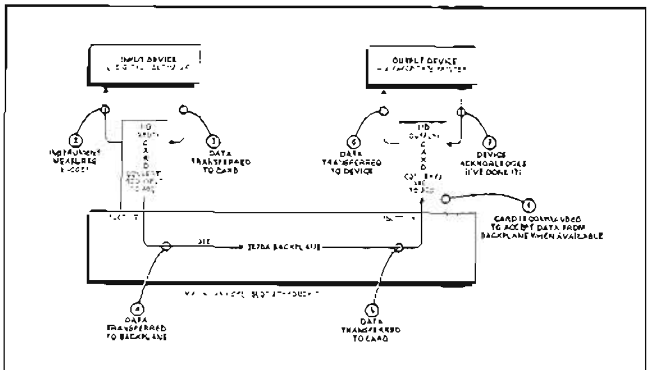
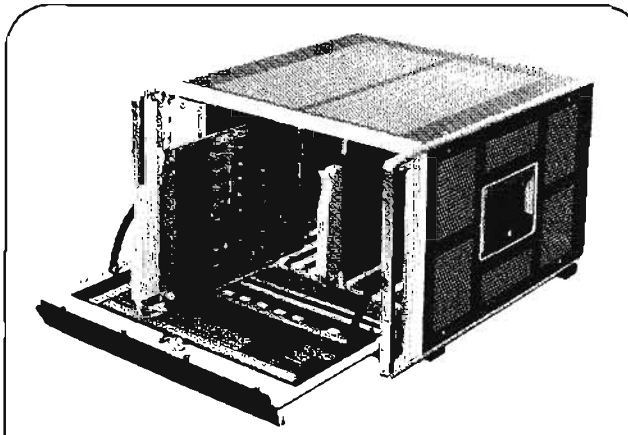


Figure 1. 2570A Single-Source, Single Output System

The highly diversified operating capabilities of the coupler/controller are all implemented under program control. All I/O operations can be programmed by either a self-contained pinboard programmer (up to 15 instructions) on the control card or by an external ASCII source, such as a teleprinter keyboard or tape reader.

Interface cards

Interface cards for many applications are available as kits specifically for the 2570A. The interface cards generate the necessary interface control signals, provide storage if required, and provide the necessary control logic for I/O operations, e.g., proper timing conditions. The following is a brief description of interface cards available.



The HP Coupler/Controller (with Front Panel Open) Accepts up to Eight I/O Devices.

The HP 12797A (2019A Opt 100) BCD Input Card equips the 2570A to receive the digital output from a variety of instruments, including voltmeters, and counters. The card translates up to 10 characters of 8421 BCD information from a digital source into ASCII and makes it available in serial form on the 2570A ASCII bus. Patch panel programming on the card permits format control of the input/output slot, and insertion of certain special characters. The HP 12797A BCD Input card interfaces the following Hewlett-Packard instruments to the 2570A: Counters: 5221A/B, 5245L, 5321A/B, 5323A, 5325A/B, 5326A/B, 5330A/B, and 5327A/B/C; DVMs: 2401C, 2402A, 3450A, and 3480A/B; 3440A, 3460A, and 3462A. 2801A Quartz Thermometer.

The HP 12798B (2019A Opt 119) BCD Output Card provides a 10-digit parallel data output register as a means to interface the 2570A with parallel entry digital devices. The card can also be used as a general-purpose 40-bit output register. The HP 12798B BCD Output Card is compatible with the following Hewlett-Packard instruments: Digital Recorders: 562AR, 5050A/B, 5055A; DVMs: 3450A, 3480A/B; Digital Voltage Sources: 6130B-J80, 6131B-J80. Counters: 5325B, 5326A/B; 6936A Multiprogrammer.

The HP 12799B (2019A Opt 140) 16-Bit Relay Register provides 16 programmable contact closures for control of external devices such as power supplies, solenoids, electrically activated control valves, or instruments requiring control voltage outside of the normal logic ranges. The contact closures may be subdivided in any combination for controlling one or several devices. The voltages switched through the relay contacts can differ from each other and from the 2570A ground by as much as 100 volts peak. Contacts can be connected in series, parallel, or series-parallel, with or without diode isolation. Floating contact closure permits switching of diverse voltages and avoids ground loops. Also programs DMVs: 2401C, 2402A, 3440A, 3460A, and 3462A.

The HP 12800A (2019A Opt 160) 8-Bit Duplex Register provides the 2570A with the capability to interface directly with 2100 series computers, the 2753A High Speed Tape Punch, and the 2748A/58A High Speed Punched Tape Reader. Commonly, the distance between the coupler/controller and other devices can be handled by the 12-foot cables available for this purpose. Interconnect cables are available to allow the punch and reader to be operated independently or simultaneously.

The HP 12801A (2019A Opt 180) Teleprinter Interface allows the HP 2752A Teleprinter to interface with the HP 2570A. A system incorporating a 2570A can be manually controlled by entering instructions from the teleprinter keyboard. Alternatively, the system may be controlled by paper tape programs read from the teleprinter tape reader.

The HP 12802A (2019A Opt 200) Interface for HP 9100 Series Calculators and the HP 12822A (2019A Opt 201) Interface for HP 9800 Series Calculators enable the HP 2570A to communicate directly with the calculators. Data can be input through the 2570A to the calculator x-register and conversely, processed data can be output from the x-register through the 2570A, to such devices as a teleprinter or tape punch. Additionally, the program storage capability of the calculators can be used to exercise system control. Through the use of a few simple keystrokes, the calculator can take readings from DVMs, counters, etc., control scanners, program power supplies, and in essence, do any of the things that can be done through the internal pinboard program. Furthermore, the calculators bring computational power and decision making capability to the system for minimal cost.

The HP 12803A (2019A Opt 220) Ten-Channel Reed Relay Scanner switches multiple analog input signals, in either numerical or random sequence, to a single measuring device such as a DVM or frequency counter. Reed relays switch up to 10 channels per plug-in card. With multiple scanners, up to sixty analog input channels can be switched to the DVM or counter with a single 2570A-based, data acquisition system. A two-digit channel identification is available for recording along with the data, or it may be suppressed, if desired.

The HP 12807A (2019A Opt 300) Pinboard Program Card provides 45 additional program steps for the 2570A. The steps are divided into five separate nine-step program segments, each of which can be treated as a separate subprogram that can be addressed directly and executed. A null step (no diodes inserted) determines the end of that subprogram. Program chaining is possible for programs longer than nine steps. More than one program card can be used at a time, greatly expanding programming capability.

The HP 12809B (2019A Opt 320) Time-Sharing Interface enables the 2570A to establish two-way communication with a time-shared computer. Any device interfaced to the 2570A also becomes interfaced to the computer, thereby enabling instruments and peripheral devices to communicate with each other and the computer. Thus, a computer program can control devices in a measurement system. The time-sharing interface (and an appropriate acoustical coupler) allows data to be transferred on-line to a time-shared computer for analysis without the need for manual data logging and the subsequent re-keying of information into a computer terminal. Logging is performed unattended and automatically. All the mass data storage and powerful processing power of the most sophisticated computers are readily available without the capital outlay for an in-house system. Other benefits include access to pre-written statistical routines, capability of accumulating large historical files, and storing sophisticated programs at a low cost; these files are available on instant recall, making it possible to get maximum usage from the computer.

The HP 12811A-001 (2019A Opt 341) Clock/Timer/Pacer Card adds very flexible measurement timing capabilities to the 2570A. The exact time of day can be recorded along with instrument data. Individual data points or complete measurement scans can be programmed (paced) with switches to begin at specified time intervals, at 0.1 sec increments from 0.1 sec to 99.9 sec (or 0.1 ms to 99.9 ms). Also, by means of the clock, intervals can be once every 0.1 sec, 1 sec, 10 sec, 1 min, 1 hr, or only once every day. Clock intervals can be multiplied (jumper placement) by 2 or 3. Additionally, time delays may be inserted in the program in 0.1 sec increments from 0.1 sec to 99.9 sec (or 0.1 ms to 99.9 ms). The clock operates from a 100 kHz crystal oscillator. An emergency power circuit keeps the clock running in event of power failure.

The HP 12812A (2019A Opt 360, 361, and 362) Incremental Magnetic Tape Interface Kits operate with most Kennedy Model 1600 and 1610 Series Recorders. (The interfaces are available as separate kits which include an interface card and cables, or complete with an incremental tape recorder.) Interfaces are available in either write-only or read/write versions. Write-only interfaces allow data to be recorded in IBM-compatible format; data are reduced by reading the data from the tape on a separate tape drive input to a computer system. Read/write interfaces allow data to be recorded incrementally and also read out for transmission to a data analysis system. Although recording (writing) is incremental, data are read continuously at high speed for maximum transfer efficiency. Recording density can be 200, 556, or 800 bpi, depending on the recorder.

The HP 12817A (2019A Opt 052) Parity Generator Interface generates even or odd parity for data that have no parity, as a means to enable a computer interfaced to a 2570A to detect transmission errors. Since some computer systems can only accept data with parity, the parity generator then enables an instrumentation system interfaced to the 2570A to enter data into such computer systems. The parity generator is especially useful for introducing parity into punched tape during data acquisition, since such tapes cannot be edited later.

Prices

HP 2570A (HP 2019A Opt 001); includes installation, power cable, and control card, $1875.

HP 12797A (HP 2019A Opt 100) BCD Input Interface Card, $750.

HP 12798B (HP 2019A Opt 120) BCD Output Interface Card, $700.

HP 12799B (HP 2019A Opt 140) 16-Bit Relay Register Interface Card, $600.

HP 12800A (HP 2019A Opt 160) 8-Bit Duplex Register Interface Card, $600.

HP 12801A (HP 2019A Opt 180) Teleprinter Interface Kit, $450.

HP 12802A (HP 2019A Opt 200) HP 9100 Series Calculator Interface, $1775.

HP 12822A (HP 2019A Opt 201) HP 9800 Series Calculator Interface, $1500.

HP 12803A (HP 2019A Opt 220) Ten-Channel Reed Relay Scanner, $600.

HP 12807A (HP 2019A Opt 300) Pinboard Program Card, $750.

HP 12809B (HP 2019A Opt 320) Time-Sharing Interface, $1500.

HP 12811A (HP 2019A Opt 341) Clock/Timer/Pacer Card, $1560.

HP 12812A (HP 2019A Opt 360) Incremental Magnetic Tape Interface, $1400.

HP 12817A (HP 2019A Opt 052) Parity Generator Interface Card, $150.

Applications

The 2570A is capable of serving in many different system applications, some of which are listed below.

1. Stand-alone system. The 2570A interfaces BCD instruments to an output recorder.

2. Calculator-based automatic test system. The HP Calculator adds decision making capability to a test system. The 2570A interfaces BCD measurement instruments, stimulus to the device under test, and the calculator.

3. Computer-based system. One or more coupler/controllers are used to extend and remote the computer I/O system, thus allowing multiple test stations to be under control of a single computer.

4. Time-sharing system. Single or multiple coupler/controllers interface test systems to time-sharing systems, thus enabling access to an on-line computer without investing in an in-house system.

An overall general description of the 2570A along with brief descriptions of compatible Hewlett-Packard instruments is described in Application Note 130. Application Note 131 describes the 2570A in computer time-sharing systems, and Application Note 132 describes the 2570A in Hewlett-Packard calculator systems. These application notes are available from Hewlett-Packard without charge.

Calculator-based systems

Three basic types of systems can be configured by the addition of a Hewlett-Packard calculator to the coupler/controller. These are:

(1) Punched tape data processing systems where the calculator reads data from punched paper tape through a teleprinter. Calculations such as linear regressions, histograms, and various statistical routines fall easily within the calculator's capability.

(2) Data acquisition systems which are substantially lower in price than a conventional computer system. All data acquisition and programming is accomplished by selecting the appropriate keys on the calculator.

(3) Automatic test systems with a stimulus-response-calculation capability at an economical dollar figure.

The coupler/controller, in combination with a Hewlett-Packard calculator, form the controlling elements of an automatic test system. This capability is exemplified in Figure 2 showing the coupler/controller, calculator, quartz thermometer, and programmable digital voltage source. The system takes readings of the oven temperature, compares each reading against predetermined high and low limits, and sets the heater voltage of the oven to correct an out-of-limits condition. In addition, the calculator performs an extrapolation of the last five temperature readings in order to forecast the next reading; the forecast is compared against the high and low limits also. If the forecast is higher than the upper limit, the heater is programmed for a moderately low voltage to reduce the oven temperature; if the forecast is less than the lower limit, a moderately high heater voltage is set to raise the temperature. After the temperature reading and forecast comparisons (and the necessary heater voltage correction, if any) have been made, the calculator program loops back and begins a new sequence of system operations.

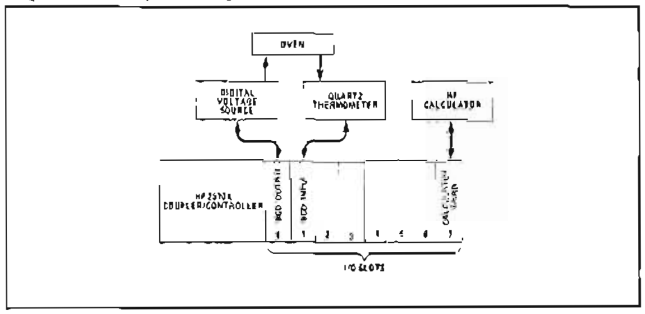


Figure 2. Coupler/Controller — HP Calculator Automatic Test System.

Remote terminal operation

The coupler/controller is particularly well suited for use as a remote terminal in applications such as testing, monitoring, and controlling. Typically, an HP 9600 Series Computerized Data Acquisition System serves as the central station with the coupler/controller located at the test site. Data and control information between the central computer and the remote coupler/controller can be exchanged by means of a single dedicated cable (to a distance of 10,000 feet), or via common carrier telephone lines by employing data sets or modems at each terminus. Thus, channels or entire terminals can be added or removed quickly and economically since communication is over a single cable or telephone circuit. The high cost and inaccuracies of multiple analog cables are avoided. Also, since each coupler/controller can scan up to 60 analog data channels, hundreds of widely distributed channels can be monitored or controlled from a single central system.

The coupler/controller can be operated either as a computer-controlled remote terminal or as a remote, callable, stored-program controller. The coupler/controller can accept step-by-step instructions from the remote computer to input and output data to instruments and operator interfaces, or it can be programmed using its internal pinboard memory to perform a specific function upon call from the remote computer. Figure 3 illustrates the major elements in the remote terminal operation.

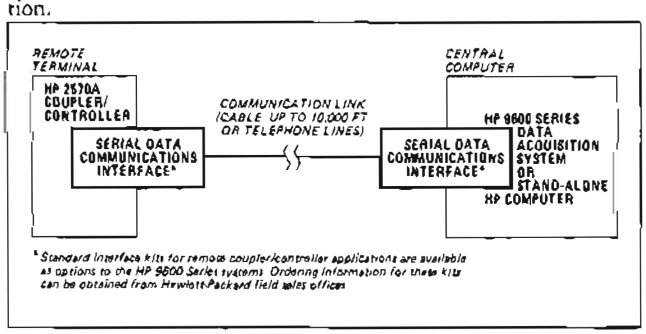


Figure 3. Major Elements for Operating the HP 2570A as a Remote Terminal.

Time-sharing-based systems

The coupler/controller can access any time-sharing system capable of communicating over voice-grade telephone lines using ASCII. Information can be transmitted and received in either half-duplex or full-duplex and with most time-shared systems equipped with an ASCII port, including G.E. Mark II and Mark IV, TYMshare, HP 2000 Series Leasco Response, S.B.C. Call 360, and others. And, since the coupler/controller is language independent, it can be used with any time-sharing language that can be transmitted on a teletypewriter including FORTRAN, BASIC, ALGOL, and PL/I. The significance of two-way communication is that the time-shared computer can exert on-line control of the peripheral devices interfaced with the coupler/controller.

Many practical time-sharing applications are possible, including: instant analysis of hospital tests, weather monitoring, collection of environmental data, analyzing engine performance (temperatures, pressures, electrical systems), and many others. The following is an application where the coupler/controller, in conjunction with a time-sharing computer system, operates in a production environment testing electronic modules.

The measurement problem was to monitor the voltage outputs of ten identical amplifier modules while they are inside an environmental test chamber. The specific test objectives were to determine whether or not the amplifiers require temperature compensation resistors, and if so, the values and defined locations for placing in the circuit. In addition, it was necessary to determine whether or not a module is outside of the compensation range or has failed. Previously, this process required approximately six hours for a technician to manually control the temperature, record the data, and make the proper decisions.

A Hewlett-Packard coupler/controller time-sharing system, Figure 4, proved to be a highly cost-effective solution to this measurement problem. Now, the tests are completed in approximately one hour. Thus, a production run of 80 amplifiers can be tested in one eight hour shift. The technician has merely to move the modules in and out of the test chamber, start the test program, and read the teleprinter printout to determine resistor locations and failed modules. The coupler/controller time-sharing system very well solved the problems of gathering large amounts of data at the various temperatures, and reducing the data to assure fast testing, hence shipment, of large production quantities. It should be noted that this system could have been operated in an off-line data acquisition mode (by operating a switch in the junction box).

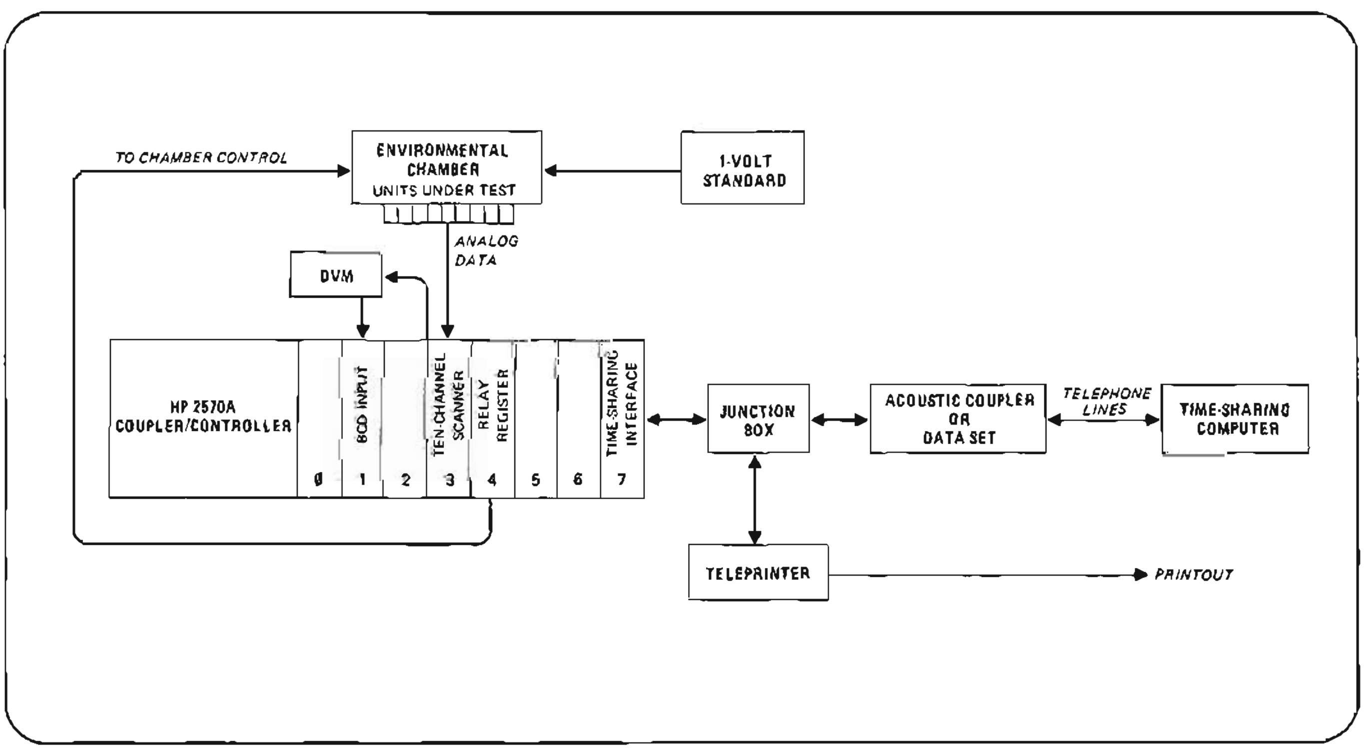


Figure 4. Coupler/Controller — Time-Sharing System for Production Testing of Electronic Modules.

Electronic counters have proven to be the most accurate, flexible, and convenient instruments available for making both frequency and time interval measurements. Since the introduction of the first high-speed counter (the 10 MHz HP Model 524A) more than 20 years ago, Hewlett-Packard has developed a broad range of counters to permit selecting the proper instrument for virtually any application.

Conventional counters

Data on these pages cover the basic concepts of the conventional frequency counter including operation, accuracy, input considerations and extended frequency response. The basics of measuring time interval are then considered and finally a new concept in frequency measurement, as provided by the Computing Counter System, is discussed. This general introduction is concluded with a counter selection chart introducing the broad range of electronic counters available from Hewlett-Packard.

Frequency measurements and the basic counter elements

The frequency of a continuous wave signal is the number of events or cycles that occur per unit time (one second). Most counters measure frequency by totalizing the number of cycles or events of the input signal for a precisely known period of time.

The basic elements of conventional counters (which excludes counters that use computation as part of their measuring process—e.g. HP 5360A Computing Counter) are: (1) the decade counting assemblies (DCA's) with numerical readouts to display the count; (2) the main gate, which controls the time over which the input signal is totalized; (3) the time base, which supplies a reference of time for the main gate; (4) decade divider assemblies (DDA's) which divide the time base output to the desired increment of time for which the main gate will be open and (5) an input amplifier-Schmitt trigger to shape the input signal for the DCA's. The counter also contains logic control which interconnects the proper circuits for the desired measurement, selects the appropriate measurement units for display and initiates the measurement cycle.

Figure (1) shows the conventional counter for frequency measurement. The number of pulses derived from the input that are totalized during the "gate open" interval is a measure of the average input frequency for that interval. The count obtained is displayed and retained until a new sample is ready to be shown. The Sample Rate control determines the time between samples, resets the counter and initiates the next measurement cycle.

The time base selector switch selects the gating interval, positions the decimal point and selects the appropriate measurement units (e.g. Hz, kHz, MHz).

Period measurements

Period is the inverse of frequency ($P = 1/f$). Therefore, period measurements are made with the input and time base connections reversed. The unknown input signal controls the main gate time, and the time base frequency is counted in the DCA's. The input shaping circuit selects the zero axis crossing of successive cycles of the unknown as trigger points for opening and closing the gate.

Low frequencies may be determined more accurately by measuring period rather than frequency directly. This is true because the longer period of a low frequency allows more counts to accumulate in a period measurement; therefore, resolution and accuracy are both improved. For example, a frequency measurement of 100 Hz on the 8-digit 5248L Counter with a 10-second gate time will display as 0000.1000 kHz. A period measurement of 100 Hz on an HP 5248L with 100 MHz as the counted frequency, would display as 010000.00 μs. Thus, resolution is increased by a factor of 10^3 and measurement time decreased by 100.

Multiple period averaging

Multiple period averaging reduces error and improves resolution in period measurements.

The number of periods of the unknown to be averaged is selectable. The HP 5326B can average up to 10^8 periods and several other HP counters can average up to 10^6 periods. In the example above, the counter would display 10000.000 μs for a 10 period average. (The selector switch automatically shifts the decimal point in the display to show the correct reading for a single period.)

Totalizing

In the totalizing mode the main gate flip-flop is controlled remotely or by a manual start-stop switch. With the switch in Start (gate open), the decimal counter assemblies totalize input pulses until the main gate is closed. The counter display then represents the input pulses received during the interval between Start and Stop.

Ratio measurements

The ratio of two frequencies is determined by using the one signal for the gate control while the other signal is counted. With proper transducers, ratio measurements may be applied to any phenomenon which may be represented by pulses or sine waves. Gear ratios and clutch slippage as well as frequency divider or multiplier operation, are some of the measurements which can be made using this technique.

Accuracy is improved by the multiple period averaging technique by counting for 10^N cycles of the gate control signal.

Rate measurements

With a preset counter, frequency measurements can be normalized automatically to rate measurements by appropriate selection of the gate time. The counter will then display a readout in the desired unit of measurement. For example: a gate time of 600 milliseconds causes the input from a 100-pulse-per-revolution

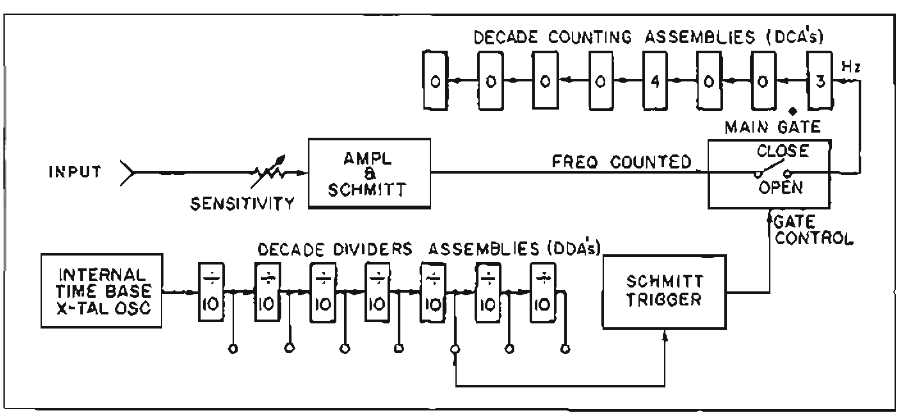


Figure 1. Function switch set to FREQUENCY and gate time selected by time base switch.

tachometer to be displayed directly in revolutions per minute.

Scaling

Several Hewlett-Packard counters can scale (divide) an input by powers of 10 up to 10^9. The scaled output is available from the rear of the counter.

Measurement accuracy

There are three main sources of error in conventional counters:

±1 count ambiguity. This is inherent in all conventional counters because input signal and time base are not synchronized, thus causing a one count ambiguity in the events totalized.

For low frequencies, where relatively few events can be totalized over practical gate times, this ambiguity contributes significant error. This is normally overcome by measuring period instead of frequency. The error is still there but can be made insignificant by selecting a high counted frequency and utilizing the period average mode.

Time base stability. Since frequency measurements are accomplished by comparing the unknown to the counter's internal oscillator or time base, any time base error translates directly into a measurement error. Error sources are:

Long term stability: The slow, but predictable, variation in average oscillator frequency with time due to the quartz crystal "aging". Aging is cumulative, so it is necessary to periodically calibrate the oscillator. See Application Note 52, available upon request.

A typical long term stability specification might read as $<5 \times 10^{-10}$/day. With no calibration for 20 days, error could be 1×10^{-8}. Thus, with a 1-second gate, the error in 100 MHz measured on an 8-digit counter could be one count ($1 \times 10^{-8} \times 1 \times 10^8 = 1$ Hz).

Short term stability. More properly called "fractional frequency deviation", is a measure of the amount of noise or instability that the oscillator exhibits. (For measuring short term stability, see Application Notes 52 and 116, available upon request.)

Oscillator noise has components at many frequencies, so short term stability varies with measurement time, generally getting smaller the longer the gate time. Thus, a specification without a statement of averaging or measurement time is meaningless. Moreover, averaging times of 10 minutes or one hour are useless since such extreme measurement times are rare.

In general, Hewlett-Packard counters are specified for 1 s averaging times. In addition, however, the oscillators are selected so that their short term stabilities do not affect accuracy no matter what gate time is used.

Line voltage and temperature. Are self-explanatory specifications. The total inaccuracy due to the time base is the sum of long term, short term, line voltage and temperature errors.

Trigger error. Trigger error arises from noise on the gate-control signal that causes the gate to open and close at incorrect times. Since significant trigger error can occur only when an external signal controls the gate, this error occurs in period measurements.

For a 40 dB S/N signal, the trigger error in a period measurement is:

$$\frac{3 \times 10^{-3}}{n} \times \frac{e_s}{e_{in}}$$

where n = number of periods averaged

e_s = counter sensitivity

e_{in} = input signal magnitude

This indicates that trigger error is only a factor for noisy, low frequency signals where n is small.

For frequency measurements the general accuracy statement is:

±1 count ± time base stability [1]

while for period measurements it is:

±1 count [2] ± time base stability ± trigger error.

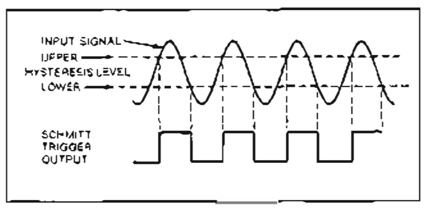


Figure 2. To be counted input signal must cross both hysteresis levels of the input Schmitt Trigger.

Input considerations

A counter's input circuit may be characterized by means of sensitivity, trigger level, ac/dc coupling, and input impedance.

Sensitivity means the minimum countable signal level. The amplifier-Schmitt trigger input circuit determines the sensitivity, since the signal applied to the Schmitt trigger must cross both its upper and lower hysteresis limits to produce an output. See Fig. (2).

The two hysteresis levels are usually located symmetrically about ground to conform to the usual situation of measuring a CW signal with no dc content. DC content is removed in the counter's ac coupling mode. If the input is a pulse train, however, the trigger level control must be used to shift the hysteresis levels out of the preset position to a position either above or below ground. see Fig. (3).

The input impedance of most Hewlett-Packard counters is either 50Ω or 1 MΩ. A 1 MΩ input is provided for most direct

1. See under time base specifications for short term, long term, temperature and line voltage stability.

2. Refers to the frequency of the counted clock (i.e. the displayed count).

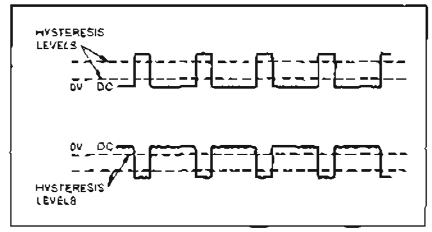


Figure 3. To enable a count on these waveforms the trigger level control must be out of PRESET to shift the hysteresis positive (upper waveform) or negative (lower waveform).

reading counters, since for frequencies up to 250 MHz this is the more versatile, avoiding loading the source connected to the counter. Above 250 MHz, however, the inherent shunt capacity of a 1 MΩ input is severely limiting; then, a matched 50Ω input impedance is offered. Since most high frequency and microwave devices operate in a 50Ω environment, the prescaler and microwave plug-ins and counters (see below) provide a 50Ω input impedance.

Increasing the frequency range

The direct counting range of the conventional Hewlett-Packard counters described so far range from 10 MHz (5300A) to 150 MHz (5248L, M). Several techniques can increase this range:

Prescaling is accomplished by placing a divider between the Schmitt trigger of Figure (1) and the main gate. If the division factor is N, the gate time is extended by the same factor to ensure a correct readout. Hewlett-Packard manufactures a number of prescalers: the 50 MHz 5302A and 525 MHz 5303B plug-ons to the 5300A, the 350 MHz 5252A and 200 MHz 5258A prescaler plug-ins to the 5245 Series counters, and the 5327 line of counters where a 550 MHz prescaler is built into the mainframe.

Operating a prescaling counter is identical to a direct reading counter. The user is rarely aware that the signal is being prescaled; it just takes somewhat longer to obtain the same resolution as a direct counter.

Heterodyne conversion is the most accurate method of measuring high frequency or microwave signals. In a given measurement time it provides the same resolution of the conventional direct counting frequency counter.

Heterodyne converters simply down convert the unknown frequency f_x by mixing with an accurately known frequency f_a, such that the difference f_d, is within the counter's range. See Fig. (4). The frequency f_a is selected by first multiplying the time base to a convenient frequency f_1, (usually the maximum direct frequency of the counter), and then passing this signal through a harmonic generator. The appropriate harmonic $Nf_1 = f_a$ (N is an integer) is selected

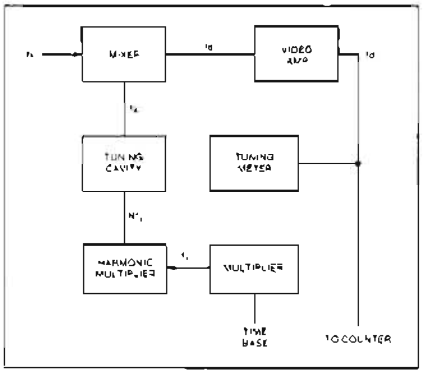


Figure 4. Basic operation of a heterodyne converter.

by the tuning cavity and passed to the mixer. The cavity is operated from a front panel control calibrated to read the frequency f_a directly. The difference frequency $(f_x - f_a) = f_d$ is amplified and measured by the counter. To the counter reading the operator adds the front panel control setting f_a to obtain the final answer f_x. The tuning meter of Figure (4) indicates when the unknown frequency has been located.

While the heterodyne converter is broad band, it is not as broad band as the transfer oscillator (see below). The band limiting culprit is the mechanical tuning cavity. The range from 150 MHz to 18 GHz is covered by Hewlett-Packard with three such heterodyne converters, the 150 MHz-3 GHz 5254C, the 3 GHz-12.4 GHz 5255A and the 8 GHz-18 GHz 5256A. In addition, the 50-500 MHz 5253B gives 500 MHz operation with the 5245L. All these converters are plug-ins to the high performance 5245 Series of counters.

Extremely broad band microwave frequency measurements can be made with the TRANSFER OSCILLATOR. Accuracy, however, cannot equal the heterodyne converter's.

The transfer oscillator principle is based on the property of harmonic mixing, that is; if f_x is the unknown input to a mixer and f_{LO} is the local oscillator, the mixer will produce an output $f_n = f_x - Nf_{LO}$ where N is an integer. The mixer frequency response determines transfer oscillator frequency range and the extremely fast sampler in the HP 5257A Transfer Oscillator gives broad band measurements from 50 MHz to 18 GHz. The relative measurement accuracy is the same as that of the local oscillator which cannot match the heterodyne converter's crystal derived reference frequency.

The 5257A block diagram is in Figure (5). To operate, the user simply tunes the local oscillator for phase lock at zero beat (i.e. $f_x = Nf_{LO}$) as indicated by a front panel meter. The local oscillator frequency is then measured by the

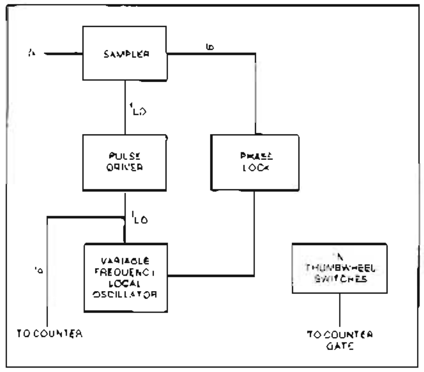


Figure 5. Basic operation of a transfer oscillator.

counter. To obtain a direct reading of the microwave frequency f_x, the 5257A is provided with thumbwheel switches, which extend the gate time of the counter by N. If f_x is completely unknown, so too is N; however, a simple technique is described in the 5257A Operating Manual for determining N.

By opening the phase lock loop (via front panel switch), the 5257A Transfer Oscillator can also measure fm deviation and the frequency of a pulsed RF signal as described fully in the 5257A Operating Manual.

The 5257A is a plug-in to the 5245 Series of plug-in counters and contributes considerably to the measurement power and versatility of this line of mainframes.

5340A Microwave Frequency Counter is an extension of the manual transfer oscillator described. The 5340A is a state of the art product in every way. It is basically an automatic transfer oscillator that allows completely automatic frequency measurements from 10 Hz to 18 GHz via a single input. In addition, it has high sensitivity and a very short acquisition time. Full details on operation will be published in a 1973 issue of the Hewlett-Packard Journal.

Time interval

In addition to the measurement described earlier, the conventional counter lends itself to measuring time intervals. Applications are many and growing and include laser and radar ranging, integrated circuit rise, fall and delay time and nuclear time of flight measurements, to name but a few.

Hewlett-Packard manufactures a number of counters offering a wide range of time interval capability. Single shot (a single pulse) time interval resolution as good as 1 μs to 100 ps can be obtained.

The basics of time interval measurements

Figure (6) illustrates the key elements of a time interval meter. The main gate is controlled by two independent inputs, the START input or channel and the STOP channel. When an external signal is applied to the start input, the main gate is opened and the DCA's accumulate clock pulses derived from the internal reference oscillator. When a stop signal occurs, the main gate closes and the accumulated count in the DCA's represents the time between the occurrence of start and stop signals.

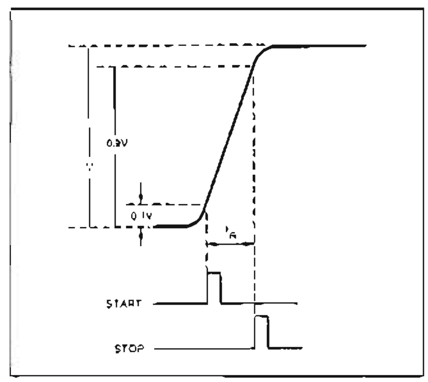


Figure 7. Measuring the rise time t_R by adjusting the trigger levels to the 10% and 90% points of the input amplitude.

The frequency of the counted clock determines measurement resolution, (e.g. a 10 MHz clock provides 100 nsec resolution). Obviously, the input amplifier/trigger and the main gate must operate at speeds consistent with the clock frequency, for otherwise the instrument's resolution would be meaningless. Present state of the art limits resolution to about 10 nsec; however, several Hewlett-Packard counters utilizing special techniques described below offer substantially better resolution than this.

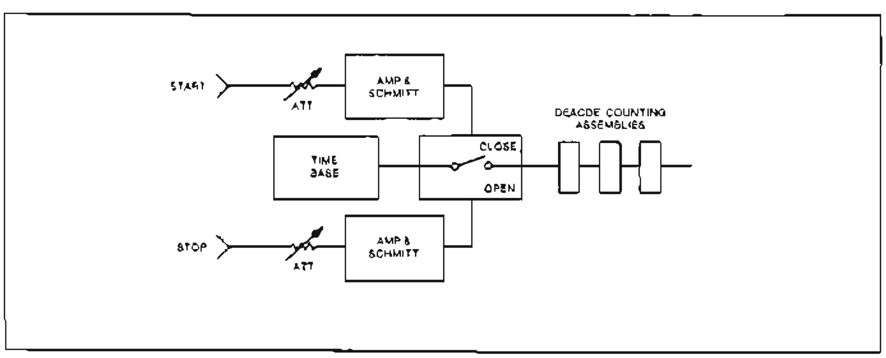


Figure 6. The basic elements of a time interval meter.

Time internal—A two dimensional problem

The dimensionability of time interval may be described by the simple example in Fig. (7): measuring signal rise time. The time interval meter must generate a start signal at the 10% amplitude point of the input signal and generate a stop signal at the 90% point. Inherent in all time interval measurements therefore are two dimensions, one of amplitude, the other of time.

To take care of the amplitude problem most time interval meters include adjustable trigger level controls for both channels. With the trigger level set at a certain voltage V_1, the channel produces an output pulse, which is applied to the main gate, when the input level reaches that voltage, V_1. In addition each channel includes slope controls so that triggering can be obtained on either the positive or negative slope of the input signal.

Thus, the input circuits of a time interval meter must of necessity be more sophisticated than that of a frequency input to take care of the extra dimension added to the problem. The differences may be summarized as:

(i) two independent input channels, one for start, the other for stop; that may be commoned right at the input so that measurments such as the rise time of a single input signal can be measured.

(ii) trigger levels on each channel that can be adjusted over a wide amplitude range (dynamic ranges of 30:1 are typical).

(iii) slope controls for each channel so that triggering can be effected at any point on the input signal within the dynamic range of the input.

Measuring trigger level

In days gone by when resolutions of less than 1 μsec were all that was required, trigger level determination was satisfactorily accomplished by the oscilloscope intensification scheme. Signals derived from the start and stop channels were routed through the time interval meter to the Z axis modulation of an oscilloscope. With the input signal displayed on the oscilloscope, the points at which triggering occurred were evidenced by intensified dots. With today's resolutions of 10 nsec or better, the inherent delays of this method cause it to be useless.

The best way of determining trigger level is to actually measure the voltage at which the trigger is set. The HP 5360A/5379A, which can measure single shot events to 100 picoseconds, provide two jacks on the front panel of the 5379A from which the voltage settings of the two trigger levels can be monitored. The HP 5326B/5327B Universal Counters go even farther, providing an internal DVM. The DVM also makes general purpose voltage measurements.

Measurement accuracy

The accuracy statement for time interval usually reads as: ±1 count ± trigger error ± time base stability.

The same comments apply for time base stability in time interval and frequency measurements. Trigger error is rarely a factor since time interval measurements are usually made on relatively fast pulses. The ±1 count (which refers to the clock frequency) is again the dominant factor.

Not included in the usual accuracy statement, but nevertheless extremely important, is trigger level settability. The importance of this is that errors in poorly set trigger levels can swamp any and all of the factors described above.

Increasing the resolution

Hewlett-Packard pioneered two ways of increasing the resolution of time interval measurement over and above that derived from the basic clock:

1. **Time interval averaging:** This technique is based on the fact that if the ±1 count error is truly random it can be reduced by averaging a number of measurements. The words "truly random" are significant. For time interval averaging to work the time interval must (i) be repetitive and (ii) have a repetition frequency which is asynchronous to the instrument's clock.

Under these conditions the resolution of the measurement is:

$$\frac{\pm 1 \text{ count}}{\sqrt{N}}$$

where N = no. of time intervals averaged.

With averaging, resolution of a time interval measurement is limited only by the noise inherent in the instruments. The HP 5326/27 provide a resolution of better than 50 picoseconds utilizing this technique.

This is not the whole story, however, since the averaging described to date suffers one severe limitation; namely, the minimum measurable time interval remains at the period of the clock. This limitation is removed in the HP 5326/27 Series of counters, by unique circuits known as synchronizers.

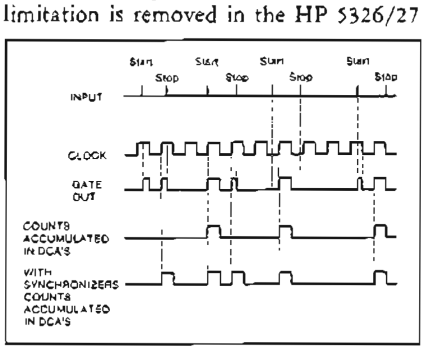


Figure 8. Synchronizer operation with time interval averaging.

The **Synchronizers** (available only in HP 5326/27 counters at this time) operate as in Figure (8). The top waveshape shows a repetitive time interval which is asynchronous to the square wave clock. When these signals are applied to the main gate, an output similar to the third waveform results. Note that much of this output results in transitions of shorter duration than the clock pulses. DCA's designed to count at the clock frequency dislike accepting pulses of shorter duration than the clock. The counts accumulated in the DCA's will therefore be those shown in the fourth trace. Since the time interval to be measured is slightly greater than the clock period, the fourth waveshape shows that the averaged answer will be in error, having been biased low because the DCA's require a full clock pulse to be counted.

This problem is alleviated by the synchronizers which are designed to detect leading edges of the clock pulses that occur while the gate is open. The waveshape applied to the DCA's, when synchronizers are used, is shown by the fifth waveform. The leading edges are detected and reconstructed, such that the pulses applied to the DCA's are of the same duration as the clock.

Synchronizers are a necessary part of time interval averaging; without them the averaged answer is biased to a value less than the true average. In addition, it may easily be seen that with synchronizers involved, time intervals of much less than the period of the clock can be measured. The HP 5326/27 Counters utilize this technique to measure time intervals as small as 150 picoseconds when averaged, even though the clock period is 100 nsec.

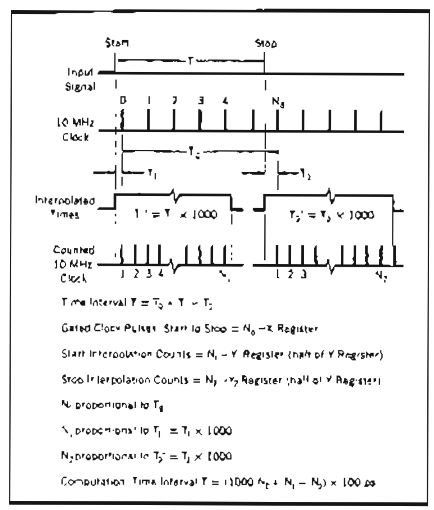


Figure 9. Time intervals measured by 5360A Computing Counter.

2. **Interpolation:** In interpolation the inherent ±1 count ambiguity is measured

and thereby removed. See Figure (9). The time interval T can be written as

$$T = T_0 + T_1 - T_2$$

where T_0 is the time indicated by counting the basic clock frequency and T_1, T_2 are the inherent time ambiguities between the clock and the start and stop pulses respectively.

The start interpolator charges a capacitor for the time T_1 and then discharges it for a duration 1000 times longer. During the discharge time the clock is again counted resulting in N_1 counts. The stop interpolator performs in exactly the same manner, resulting in N_2 counts. Coincidentally, the time T_0 is measured in the conventional manner resulting in N_0 counts. It is easily seen that the time T is represented by the simple formula

$$T = 1000\, N_0 + N_1 - N_2$$

The resolution of the measurement has been increased 1000 times by interpolation. The system behaves exactly as if the counted clock were 1000 times faster. There is no limitation on the input, and events which occur only once can readily be measured. Interpolation does require arithmetic capability in the instrument; however, this can be put to good use in many ways. One is that it allows zero time interval (coincidence) to be measured and even negative time interval. Thus, not only magnitude but sign or which event occurred first can be determined.

The HP 5360A Computing Counter System utilizes exactly this scheme. The counted clock is 10 MHz but the instrument behaves exactly as if it were 10 GHz, providing 100 pico second resolution.

Period counting

The measurement of the period of a signal rather than its frequency offers several distinct advantages. Until recently, however, the power of period counting could not be utilized because of one overriding disadvantage; the displayed answer is in terms of the period of the signal rather than its frequency. With the advent of the modern integrated circuit this disadvantage is removed, since it is now practical to compute and display the frequency from the period information contained after the measurement. The HP 5360A Computing Counter is a period measuring instrument, and with its full arithmetic capability all the advantages of period counting become a reality. These advantages are described below.

Accuracy

The frequency content of a sinusoidal signal is contained in just one cycle. In the frequency counting mode, one cycle results in one count. Conversely, with period counting, the number of counts depends solely on how high the frequency of the counted clock is in relation to the input frequency. Therefore, in any given measurement time, period counting has greater resolving power than frequency counting provided the frequency measured is less than the counted clock. The preceding section showed that the HP 5360A has the resolving power equivalent to a 10 GHz clock. Interpolation provides an accuracy five times less than the resolution (2 GHz effective clock) yet this is easily sufficient to make the 5360A the most accurate frequency measuring device available. Moreover, as Figure (10) shows, this accuracy is independent of frequency, in contrast to the conventional counter. A one second measurment of a 1 MHz signal, for example, provides an accuracy of 1 Hz with any conventional frequency counter, whereas the HP 5360A accuracy is 0.0005 Hz! The HP 5323A is a low frequency period counting instrument and its accuracy is also summarized on Figure (10).

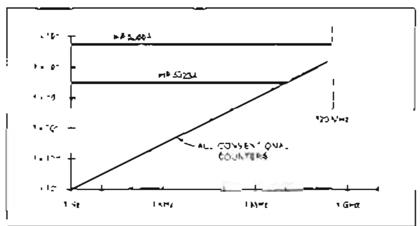


Figure 10. Comparing the measurement accuracy of the HP 5360A Computing Counter to all conventional counters.

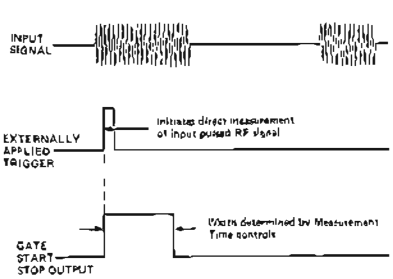


Figure 11. Direct measurement of pulsed RF by external triggering.

Triggered measurements

With period counting, the gate and input signal are synchronous, enabling triggered measurements on pulsed RF signals. See Figure (11). By triggering the HP 5360A on when a burst is present, a direct measurement of the pulsed signal can be made to counter accuracy.

This ability to trigger the beginning of a measurement at any point in real time implies a whole class of signals can now be measured. Using the 5245 Series heterodyne converters, the HP 5360A can measure pulsed RF signals from dc to 18 GHz. The ability to measure at any point in the burst enables the frequency profile of pulse compression, frequency agile and Doppler radar systems to be measured. In addition to these radar oriented signals, frequency shift keyed, frequency modulated and transient signals can also be measured.

Most conventional counters do not provide this capability; the gate closure is a function of the time base. By presetting the DDA's to 9 (e.g. HP 5326/27), however, the gate can be closed via external control to enable burst measurements to be made. However, the resolving capability of such instruments limit their application in the areas mentioned above.

The computing counter system

The measurement capability of the HP 5360A described above requires of the instrument the arithmetic capability to add, subtract, multiply and divide. This arithmetic capability has been made available to the user via several programming accessories. This allows the user to program the system to solve equations, where measurements are the variables, in real time.

The arithmetic capability of the HP 5360A System makes it a *computerized* instrumentation system, where the instrument performs the measurements and the resultant raw data is reduced to a final form by the computer. Precision measurement plus computation is the key feature of the HP 5360A System, *precise*, total solutions to complex problems the resultant benefit. General application areas for the total system include data reduction, statistical analysis and process control. For additional details refer to the counter selection guide.

The table below shows arithmetic operations accessible by external programs and is an indication of the computing power of this unique instrument. Even greater computing power is expected to be available in accessories now under development.

Code 16	8	4	2	1	Name	Description	Register Contents After Operation* X	Y	Z
0	0	0	0	0					
0	0	0	0	1					
0	0	0	1	0	MODULE	Call Module Subprogram			
0	0	0	1	1	PLUG-IN	Call Plug-in Subprogram			
0	0	1	0	0					
0	0	1	0	1	√X	Square-Root Subroutine	$\sqrt{a}$		
0	0	1	1	0	CHECK	Call Check Subprogram			
0	0	1	1	1	CAL	Call Calibrate Subprogram			
0	1	0	0	0	DISPLAY X	Display contents of X register	a	b	c
0	1	0	0	1	10X	Multiply X by 10	10a	b	c
0	1	0	1	0	ADD	Add X to Y	a+b	b	c
0	1	0	1	1	SUBTRACT	Subtract X from Y	b−a	b	c
0	1	1	0	0	1/X	Reciprocal of X	1/a	b	
0	1	1	0	1	LOAD	Enter New Number	x'	a	c
0	1	1	1	0	DIVIDE	Divide Y by X	b/a	b	
0	1	1	1	1	MULTIPLY	Multiply Y by X	ab	a	b
1	0	0	0	0					
1	0	0	0	1	X↔A	Interchange X and A**	S_A	b	c
1	0	0	1	0					
1	0	0	1	1	A→X→Y	Copy A into X and X into Y	S_A	a	c
1	0	1	0	0	2X	Add X to X	2a	b	c
1	0	1	0	1	X↔Y	Interchange X and Y	b	a	c
1	0	1	1	0	CLEAR X	Reset X to Zero	0	b	c
1	0	1	1	1	X→Y	Copy X into Y	a	a	c
1	1	0	0	0					
1	1	0	0	1	X↔B	Interchange X and B**	S_B	b	c
1	1	0	1	0					
1	1	0	1	1	B→X→Y	Copy B into X and X into Y	S_B	a	c
1	1	1	0	0	X/10	Divide X by 10	a/10	b	c
1	1	1	0	1	X↔Z	Interchange X and Z	c	b	a
1	1	1	1	0	CLEAR X Y Z	Reset X, Y, and Z to Zero	0	0	0
1	1	1	1	1	Z→X→Y	Copy Z into X and X into Y	c	a	c

*Contents before operations: X = a, Y = b, Z = c

**A is a storage register in the mainframe. Contents: S_A
B is a storage register that can be provided in an external device. Contents: S_B

Counter Selection Guide

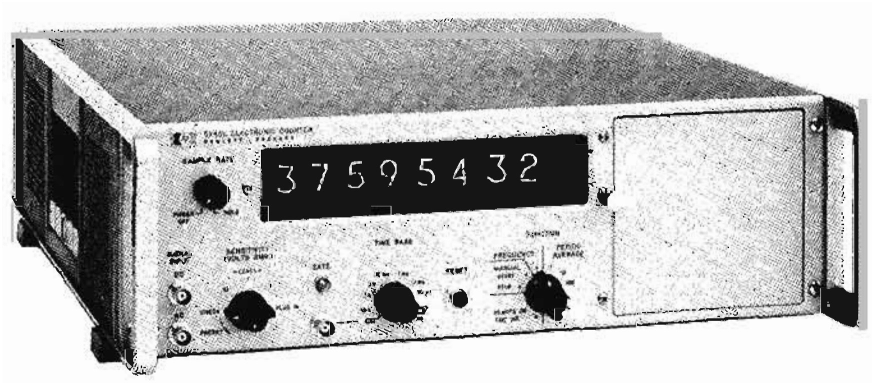
Classification	Description	Frequency	Functions*	Time Base	Price	Page
5300 Series Economic Portable	Plug-on versatility-select appropriate plug-on to meet your needs. Battery operation option for use where standard power outlets not available.	to 525 MHz	F, P, MPA, T.I., T. R.	3×10^{-7}/mo optional 1×10^{-7}/mo (5303B)	from $540	258
5326/27 Series Universal Counters	A family of six counters providing universal measurement versatility, includes sub nanosecond time interval measurements via averaging, a built-in integrating DVM and cw or burst frequency measurements.	to 550 MHz	F, P, MPA, T.I., T.I. average, T, R, V	optional up to 5×10^{-10}/day	from $995	264
5360 Computing Systems	Precision measurement plus computation. Most accurate frequency measuring device available. Time interval to 100 psec. Provides solutions that formerly required the use of a computerized instrumentation system.	320 MHz; to 18 GHz with 5245 plug-ins	F, P, MPA, T.I. and other functions derived from real time arithmetic capability	5×10^{-10}/day	from $6500	272
5245 Series High Performance Plug-in	A family of 5 mainframes and 12 plug-ins provide unmatched versatility. Plug-ins provide 18 GHz, 10 nsec time interval, voltage and preset capability.	to 150 MHz mainframe, 18 GHz with plug-ins	F, P, MPA, T.I., T, R, V	optional up to 5×10^{-10}/day	from $2050	253
5340 Microwave Counter	Ultra broadband, high sensitivity microwave frequency counter. 1 Hz to 18 GHz via single input.	18 GHz	F	optional up to 5×10^{-10}/day	$5300	270
Miscellaneous and Industrial	5210A 20 MHz Analog Frequency Meter and FM Discriminator 5323A Automatic High Resolution 20 MHz Frequency Counter 5332B 2 MHz Present Controller/Counter 5330A/B Programmable Preset Time-Base and Preset Limit Counter				$ 850 $1650 $1325 $1275	276 276 275 275

*F = Frequency
P = Period
MPA = Multiple Period Average

T.I. = Time Interval
T = Totalize
R = Ratio
V = Voltage

HIGH PERFORMANCE COUNTERS
50 MHz and 150 MHz plug-in counters
5245 series

- highest performance in general purpose counters
- wide selection of plug-ins provide unmatched versatility
- extremely high reliability proven from over forty million hours of field operation



5245L

Hewlett-Packard 5245L plug-in counter
the industry standard for high performance counters

The Hewlett-Packard 5245L is representative of the highest performance attainable in a general purpose counter. This instrument, which is the heart of the 5245 series, has become the industry standard . . . for instruments of its type, there are more 5245L counters in operation today than all the rest put together.

The 5245 series consists of a family of mainframes (described on P. 255) and a series of plug-ins (see Pages 256, 257). The plug-ins provide frequency measurement to 18 GHz, high sensitivity, time interval and preset capability. The wide choice of mainframes and plug-ins means that virtually any measurement task performable by counters can be accomplished by appropriate selection within this family.

The following is a description of the 5245L mainframe including salient specifications. The other mainframes in the family are similar to the 5245L and the differences are delineated on Page 255. Brief descriptions of the available plug-ins are given on Pages 256, 257. The reader is referred to the Frequency and Time Measuring Instrumentation tutorial on Page 248 for additional information on plug-in operation, and the 5245 series data sheet for complete details and specifications on all mainframes and plug-ins.

5245L Mainframe

The 5245L mainframe has the capability to measure frequency, period, multiple period average, ratio and multiple ratio. It can also be used to scale or divide a frequency in powers of 10 and to totalize random or periodic events. The basic counter offers a counting rate of 50 MHz with a 8 digit resolution.

Time Base: The internal time base of the 5245L is of sufficient accuracy and stability to serve as a secondary standard. Even so, a higher quality time base is offered (M type version). Specifications for all 5245 series time bases are given on Page 255.

Basic Operation: For frequency measurements gate times from 1 μsec to 10 seconds may be selected via the front panel TIME BASE switch. The FUNCTION switch enables period and period average to 10^5 to be performed. This capability makes possible accurate frequency determination at low and intermediate frequencies.

Basic sensitivity is 100 mV rms but for higher level signals the attenuator (SENSITIVITY) can be used. A variable trigger level (LEVEL) is also provided to enable counting of positive or negative going pulses. In counting a sinusoidal signal, the LEVEL switch is put in the PRESET position. The input signal may be ac or dc coupled, the former being used to remove the dc content of a signal, the latter for counting pulses. The SAMPLE RATE control varies the rate at which measurements are taken from 5 per second to infinite in the HOLD position.

A four line binary-coded-decimal (BCD) digital output is provided from the rear of the counter. This can be used to obtain permanent printed records of measurements via digital recorders such as the HP 562A, 5050B, and 5055A. For providing strip chart plots of continuously varying phenomena, the HP 580A, 581A digital-analog converters can be used.

For use in systems, an Option (H65) is provided that allows complete remote control of all front panel controls.

The versatility of the mainframes and plug-ins notwithstanding, a number of options are offered on the mainframes. The reader is referred to the 5245 series data sheet for full descriptions.

Specifications 5245L

Frequency measurements

Range: dc coupled, 0 to 50 MHz; ac coupled, 25 Hz to 50 MHz.

Gate time: 1 μs to 10 seconds in decade steps.

Accuracy: ±1 count ± time base accuracy.

Readout: kHz or MHz with positioned decimal point; units annunciator in line with digital display.

Shelf-check: counts 10 MHz for the gate time chosen.

Period average measurements

Range: Single Period .... 0 to 1 MHz
Multiple Period .... 0 to 300 kHz.

Periods averaged: 1 period to 10^5 periods in decade steps.

Accuracy: ±1 count ± time base accuracy ± trigger error.

Readout: s, ms, or μs, with positioned decimal point; units annunciator in line with digital display.

Self-check: checks operation from 1 period to 10^5 periods.

Ratio measurements

Displays: (f_1/f_2) times period multiplier; multiplier: $1\text{-}10^5$.

Range: f_1:0 to 50 MHz. f_2:0 to 1 MHz in single ratio, 0 to 300 kHz in multiple ratio; ratios averaged 1 to 10^5 in decade steps.

Sensitivity: 0.1 V rms, each input (max).

Accuracy: ±1 count of f_1 ± trigger error of f_2. f_1 is applied to the decimal counters (enters "Ext." jack on front panel); f_2 is applied to decade dividers (enters Signal Input jack).

Readout: dimensionless; decimal point positioned for number of periods averaged.

Self-check: Period Average Shelf-check applies.

Scaling

Frequency range: 0 to 50 MHz.

Factor: by decades up to 10^8, switch slected on rear panel.

Input: front panel, Signal Input jack.

Output: in place of time base output frequencies.

General

Display: 8 digits in-line; 99,999,999 maximum display.

Display storage: holds reading between samples; rear panel switch overrides storage.

Sample rate: time following a gate closing during which the gate may not be reopened is variable from <0.2 s to 5 s in Frequency mode, independent of gate time; display can be held indefinitely.

Signal Input

Sensitivity: 100 mV rms.

Coupling: ac or dc, separate BNC connectors.

Impedance: 1 MΩ in parallel with approx. 25 pF, all ranges.

Attenuation: step attenuator (SENSITIVITY switch) provides nominal sensitivities of 0.1, 1, and 10 V rms.

Trigger level adjustment: front panel control has ±0.3 V trigger level range on 0.1 V position, ±3 V range on 1 V position, ±30 V range on 10 V position. A PRESET position automatically centers trigger level at 0 V.

Overload protection: diodes protect input circuit for up to 120 V rms (<500 Hz) on 0.1 V range, 240 V rms on 1 V range, 500 V rms on 10 V range. Input resistance for overload conditions (input amplitude > ten times SENSITIVITY) is 100 kΩ on 0.1 V range, and is approximately 1 MΩ on other ranges.

Pulse measurements: front panel TRIGGER LEVEL adjustment allows counting positive or negative pulses.

External input (selected by front panel Time Base switch):

Maximum sensitivity: 100 mV rms.

Impedance: 1 MΩ, approx. 20 pF, dc coupled.

Overload: diodes protect input circuit up to 120 V rms (<500 Hz).

Digital output: 4-line BCD 4-2-2-1, "1" state positive; includes decimal point and measurement unit. "0" STATE LEVEL: −8 V. "1" STATE LEVEL: +18 V.

Impedance: 100 kΩ, each line.

BCD reference levels: approximately +9.5 V, 350Ω source; approximately −1 V, 100Ω source.

Print command: +13 V to 0 V step; dc coupled.

Hold-off requirement: +15 V min., +25 V max. from chassis group (1000Ω source).

Cable connector: Amphenol 50-pin 57-30500-375, HP Part No. 1251-0086, 1 required.

Operating temperature range: −20°C to +65°C.

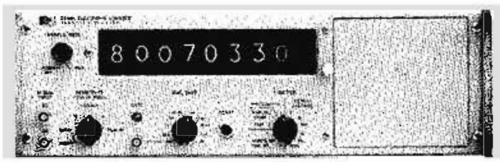
Power supply: 115 or 230 volts ±10%, 50 to 60 Hz; 95 watts.

Weight: net, 32 lbs (14,4 kg) with blank plug-in panel; shipping, 40 lbs (18,2 kg).

Connectors: BNC (except remote program and BCD out).

Accessories furnished: 10503A Cable, 4 ft (120 cm) long, male BNC connectors. Detachable power cord 7½ ft (200 cm) long, NEMA plug. Circuit Board Extender, rack mount conversion parts.

Dimensions: 5¼" high, 16¾" side, 16⅜" deep (133 x 425 x 416 mm).



5245L/M

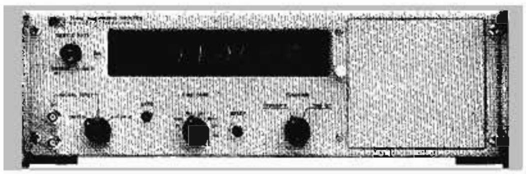
Frequency range: dc to 50 MHz.

Mainframe measurement functions: frequency, period, period average, ratio, scaling.

Compatible plug-ins: all, see pages 256-257.

L and M versions: differ only in time base specification. See below. General specifications are on page 254.

Price: 5245L, $2725; 5245M, $3475.



5246L

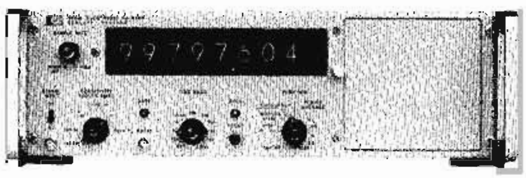
Frequency range: dc to 50 MHz.

Mainframe measurement functions: frequency only.

Compatible plug-ins: all except 5264A, see pages 256-257.

Display: 6 digits, optionally expandable to 8.

Price: $2050.



5248L/M

Frequency range: dc to 150 MHz.

Mainframe measurement functions: frequency, period, period average, ratio, scaling.

Compatible plug-ins: all, see pages 256-257.

Price: 5248L, $3100; 5248M, $3850.

L & M versions differ only in time base specification, see below. Other than frequency range, specifications are essentially same as Model 5245L/M.

Time Base Specifications, 5245 Series

5245L, 5248L

Crystal frequency: 1 MHz.

Stability

- **Aging rate:** <3 parts in 10^9 per 24 hours after 72 hours.
- **Short term:** <2 parts in 10^{10} rms with measurement averaging time of one second under constant environmental and line voltage conditions.
- **Temperature:** <2 parts in 10^{10} per °C from −20°C to +55°C.
- **Line voltage** <±5 parts in 10^{10} for 10% change in line voltage from 115 V or 230 V rms.

Adjustment: fine frequency adjustment (range approximately 4 x 10^{-8}) and medium frequency adjustment (range approximately 1 x 10^{-6}) are available from the front panel through the plug-in hole. Coarse frequency adjustment (range approximately 1 x 10^{-5}) is available at the rear of the instrument.

Output frequencies

- **At rear panel:** 0.1 Hz to 10 MHz in decade steps, selected by rear panel switch. Output is: 5 volts p-p rectangular wave with 1000Ω source impedance.
- **At front panel:** 0.1 Hz to 1 MHz in decade steps; available at "Ext." jack, selected by Time Base switch; stability same as internal time base; 1 V peak-to-peak.

External standard frequency: 1 MHz, 1 V rms into 1000Ω. Can be substituted for internal time base via rear panel EXT. STD. FREQ. connector.

5246L

Frequency: 1 MHz.

Stability

- **Aging rate:** <2 x 10^{-7}/month.
- **Temperature:** <2 x 10^{-6} (+10°C to +50°C).
- **Line voltage:** <1 x 10^{-7} 115 V, 230 V ±10%.

Output frequency: 1 MHz, >3 V p-p into 1 kΩ.

External input: 1 V rms into 500Ω.

5245M, 5248M

Crystal frequency: 5 MHz.

Stability

- **Aging rate:** <5 parts in 10^{10} per 24 hours after warm-up.
- **Short term (rms fractional frequency deviation):** better than 5 parts in 10^{11} for 1 second averaging time.
- **Temperature:** <5 parts in 10^{11}/°C from 0°C to 50°C (<2.5 parts in 10^9 within the entire span of 0°C to 50°C).
- **Line voltage:** <±1 part in 10^{10} for 10% change in line voltage from 115 V or 230 V rms.
- **Load stability:** typically <±2 parts in 10^{11} for any of the following loads: open, short, 50Ω resistive, 50Ω inductive, 50Ω capacitive.

Warm-up: for "off" periods up to approximately 24 hours: 1 hour typical to reach 5 parts in 10^9 of the frequency that existed when turned off. The 5 MHz crystal oscillator operates whenever the power cord is connected.

Adjustment: fine frequency adjustment, range approx. 5 x 10^{-8}, 16-turn control accessible through plug-in accessory compartment in front panel. Coarse frequency adjustment, range approx. 1 x 10^{-6}, 20-turn control at rear panel.

Output frequencies

- **At rear panel:** 5 MHz sine wave, 1 V rms into 50Ω. Available at all times whenever power line cord is energized, whether front panel power switch is ON or OFF.
- **At rear panel:** 0.1 Hz to 10 MHz in decade steps; switch selected on rear panel; 5 V p-p rectangular wave with 1000Ω source impedance at 1 MHz and lower; 1 V rms sine wave with 1000Ω source impedance only at 10 MHz.
- **At front panel:** 0.1 Hz to 1 MHz in decade steps; available at "Ext." jack selected by Time Base switch; stability same as internal time base; 1 V peak-to-peak.

External standard frequency: 5 or 10 MHz, 1 V rms, into 1000Ω. Can be substituted for internal time base via rear panel EXT. STD. FREQ. connector.

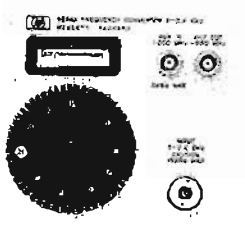
PLUG-IN ACCESSORIES

Increase 5245 Series Counter versatility

Models 5253B, 5254C, 5255A, 5256A, 5257A, 5265A

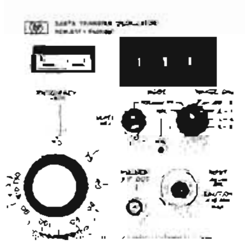
5253B

5254C

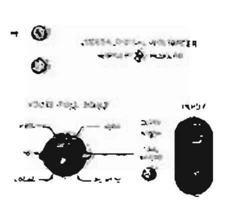


5255A

5256A



5257A



5265A

5253B HETERODYNE CONVERTER

Frequency range: 50 MHz to 512 MHz.

Sensitivity: −13 dBm to +13 dBm.

Input impedance: 50Ω.

Price: $675.

5254C HETERODYNE CONVERTER

Frequency range: 150 MHz to 3 GHz.

Sensitivity: −13 dBm to +13 dBm.

Input impedance: 50Ω.

Auxiliary output: 1 MHz—50 MHz.

Price: $925.

5255A HETERODYNE CONVERTER

Frequency range: 3 GHz to 12.4 GHz.

Sensitivity: −7 dBm to +10 dBm.

Input impedance: 50Ω.

Auxiliary input: 1 MHz—200 MHz at 5 mV sensitivity.

Auxiliary output: 1 MHz—200 MHz.

Price: $2200.

5256A HETERODYNE CONVERTER

Frequency range: 8 GHz to 18 GHz.

Sensitivity: −7 dBm to +10 dBm.

Input impedance: 50Ω.

Auxiliary input: 1 MHz—200 MHz at 5 mV sensitivity.

Auxiliary output: 1 MHz—200 MHz.

Price: $2300.

5257A TRANSFER OSCILLATOR

Frequency range: 50 MHz to 18 GHz.

Input signal: CW, pulsed RF or FM modulated.

Sensitivity: −7 dBm, 50 MHz to 15 GHz; −4 dBm, 15 GHz, to 18 GHz.

Input impedance: 50Ω.

APC lock range: ±0.2% approx. of input frequency.

VFO stability: typically 1 x 10^{-7} per minute after 2 hours.

Price: $2450.

5265A DIGITAL VOLTMETER

Voltage ranges: 10 V, 100 V and 1000 V full scale.

Resolution: 100 μV.

Accuracy: ±0.1% of reading, ±0.01% of full scale for readings <1/10 of full scale.

Sample rate: 5 per second.

Input resistance: 10.2 MΩ on all ranges.

Noise rejection: 30 dB at 60 Hz, increasing at 12 dB per octave.

Price: $825.

PLUG-IN ACCESSORIES
Increase 5245 Series Counter versatility
Models 5267A, 5262A, 5261A, 5258A, 5252A, 5264A

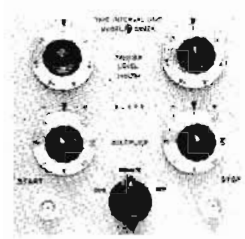
5267A TIME INTERVAL UNIT

Range: 100 nsec to 10^5 sec with 5248L/M; 1 µsec to 10^9 sec with 5245L/M; 1 µsec to 10^6 sec with 5246L.
Resolution: 10 nsec with 5248L/M only; 0.1 µsec otherwise.
Input sensitivity: 100 mV rms.
Input repetition rate: 5 MHz, max.
Input impedance: 1 MΩ/35 pF.
Markers: start, stop pulses available at rear of counter.
Price: $500.


5267A

5262A TIME INTERVAL UNIT

Range: 1 µsec to 10^5 sec (to 10^6 sec with 5246L).
Resolution: 0.1 µsec.
Input sensitivity: 100 mV RMS.
Input repetition rate: better than 2 MHz.
Input impedance: from 10K/10 pF at x0.1 multiplier setting to 10 MΩ/20 pF at x100 setting.
Markers: start, stop pulses available at rear of counter.
Price: $375.


5262A

5261A VIDEO AMPLIFIER

Bandwidth: 10 Hz to 50 MHz.
Input sensitivity: 1 mV.
Input impedance: 1 MΩ/15 pF.
Auxiliary output: 40 dB gain max into 50Ω. 300 mV rms max output undistorted into 50Ω. Source impedance 50Ω.
Price: $525.


5261A

5258A SENSITIVE PRESCALER

Bandwidth: 1 MHz to 200 MHz.
Input sensitivity: 1 mV, 10 mV, 200 mV rms.
Input impedance: 50Ω.
Scaling factor: 4.
Video amp output: 30 dB gain max at 1 mV sensitivity setting.
Price: $1025.


5258A

5252A PRESCALER

Bandwidth: dc to 350 MHz.
Input sensitivity: 100 mV rms.
Input impedance: 50Ω.
Scaling factor: 2, 4 and 8.
Price: $885.


5252A

5264A PRESET UNIT

Performs following basic functions:

(i) N x frequency, N x period, N x ratio } measurements are made by mainframe
(ii) Counts N events where input is applied to AUX INPUT of 5264A
(iii) Divides a frequency input applied to AUX INPUT by N.
Divided output available at f/N OUTPUT

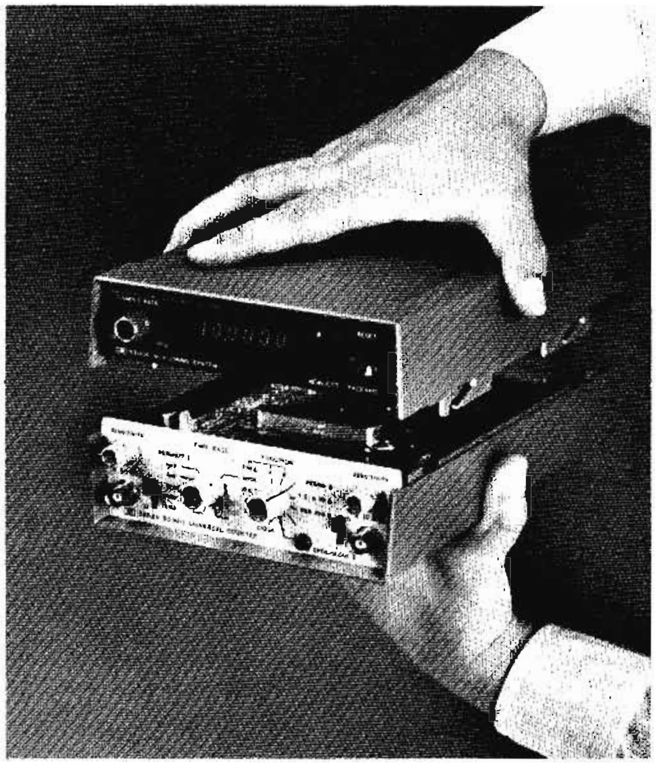
Frequency range aux input: 20 Hz to 100 kHz.
N range: 1 to 99,999 in integral steps.
Price: $850.

5264A

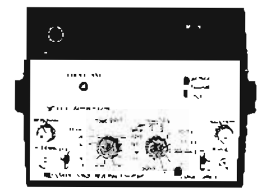
SNAP-TOGETHER COUNTER

Low cost portable counters to 525 MHz

Model 5300A Measuring System

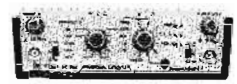


5300A Plug-On Family



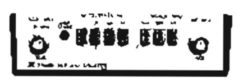
(with 5310A Battery Pack

5301A



5302A

NEW



5303B

5304A

Snap-together Modular Counter for Versatility and Non Obsolescence

5300A Measuring System

With the 5300A Measuring System, low cost counters reach new performance and versatility levels.

Features

- 10 MHz, 50 MHz, or 525 MHz frequency range
- 100 ns time interval resolution
- Autoranging
- Unique time interval holdoff
- Expandable through interchangeable modules
- High accuracy
- Battery operation
- Compact and rugged
- High reliability MOS/LSI circuitry and LED display
- Designed for quick easy servicing
- BCD output

Large scale integration and solid state display technology have produced a uniquely versatile and capable counter at a surprisingly low cost. Quick and easy to use, this counter does what is important—solves your measurement problems while saving you money. Versatility comes from modular construction—take the counter mainframe and select the snap-on module that you need now; expand the capability later with more modules if and when you need them. Hewlett-Packard is engaged in an ongoing program to develop new modules to expand the capability of the 5300A into other functional areas. An optional battery pack provides portable cord-free operation, eliminating power problems and ground loops. This is versatility that truly avoids obsolescence and optimizes your instrument dollars.

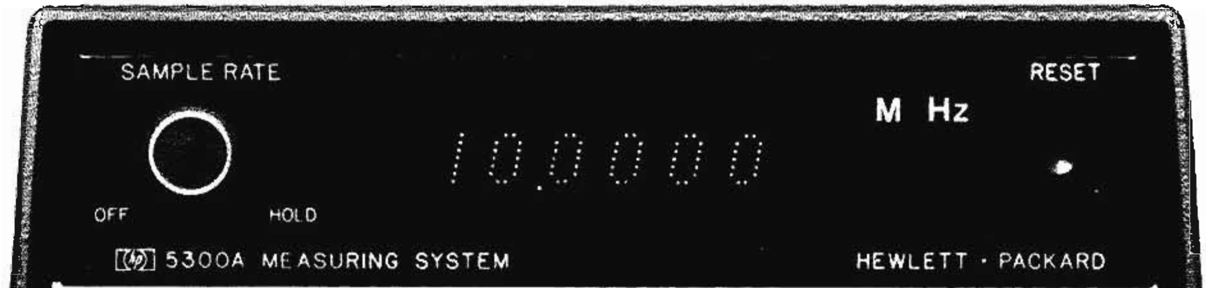
Unique benefits

The 5300A offers you a portable precision frequency counter which will measure frequencies to 525 MHz and time intervals with 100 ns resolution. The 5300A also has autoranging. Autoranging enhances ease of operation by automatically selecting the correct gate time to fill the display. Any frequency within range of the 5301A, 5302A, or 5304A may be applied and the counter will select the correct gate time up to 1 sec for maximum resolution without exceeding the display range. On the 5302A and 5304A, autoranging is also provided for the Period Average function to select the number of periods to be averaged.

A unique feature of the 5304A Timer/Counter module is the time interval holdoff. The time interval holdoff feature has been added so that a fixed delay may be added between the start of the measurement and the enabling of the stop channel. Thus electrical pulses which occur between the events that are to be measured can be ignored; e.g., a relay closure time may be measured using the time interval holdoff to prevent false triggering on the relay bounce. The delay itself can be digitally measured by the 5304A (see 5304A specifications).

The 5300A has been designed for easy servicing and minimum down time. The small number of components in the 5300A allows problems to be easily traced to a functional block. Troubleshooting is also simplified by the modular construction. The 5300A may be controlled through the connector which ties it to the modules, and a diagnostic routine will isolate problems for easy servicing. A service support package is available for this purpose (see accessories).

Features like these make the net cost of owning a 5300A Measurement System less than that of conventional counters.



5300A MAINFRAME FOR USE WITH ALL MODULES									$395
5310A BATTERY PACK FOR USE WITH ALL MODULES									$195
MODULES	FREQUENCY			TIME INTERVAL	PERIOD	PERIOD AVERAGE	TOTALIZE	RATIO	
	10 MHz	50 MHz	525 MHz						
5301A	■						■		$145
5302A	■	■		■	■	■	■	■	$275
5303B	■	■	■						$800
5304A	■			TRIGGER ■ CONTROLS		■	■		$325

Actual Size

5300A Measurement System Mainframe Specifications

Mainframe unit provides system with power, reference frequency, display, counting logic and timing control.

Time base

Crystal frequency: 10 MHz.

Stability:

Aging rate: <3 parts in 10^7/mo.

Temperature: $<\pm5$ parts in 10^6, 0° to 50°C.

Typically: $<\pm2$ parts in 10^6, 15° to 40°C.

Line voltage: $<\pm1$ part in 10^7 for 10% line variation.

Oscillator output: 10 MHz, approximately 1 V rms at rear panel BNC, 100Ω source impedance.

External input: 1 MHz to 10 MHz, 1 V rms into 200Ω.

General

Display: 6-digit solid state LED display (gallium arsenide phosphide light-emitting diodes) including decimal point and annunciator units. OVERFLOW: LED light indicates when display range is exceeded.

Display storage: holds reading between samples.

Sample rate: sample rate control adjusts the delay from the end of one measurement to the start of a new measurement. Variable from 50 ms to 5 seconds. HOLD position: display can be held indefinitely. HOLD input on rear panel connector also provides sample rate control or hold by contact closure to ground or TTL type low level.

Reset: front panel pushbutton switch resets all registers and initiates new measurement. Reset input by contact closure to ground or TTL type low level also available on rear panel connector.

Operating temperature: 0° to 50°C.

Power requirements: 115 or 230 volts ±10%, 50 to 400 Hz, 25 VA maximum (depends on snap-on module). Mainframe power nominally 5 watts.

Battery operation: with 5310A rechargeable battery pack (see 5310A specifications).

Digital output: digital serial, 4-bit BCD parallel available at rear panel connector:

Code: 4-line 1-2-4-8 BCD, "1" state low, TTL type logic levels.

Decimal point: decimal point code (Binary "1111") automatically inserted at correct digit position.

Print command: positive step, TTL output.

Inhibit: contact closure to ground or TTL low level, inhibits start of new measurement cycle.

Connector: 20-pin PC connector. Mating connector Viking 2VH10/1JN or equivalent.

Parallel data output: available with printer interface, see 10533A specifications.

Weight: net, 3⅓ lbs (1,5 kg); shipping, 5½ lbs (2,5 kg).

Accessories available:

Digital recorder interface: see 10533A specifications.

Service support package: contains an interface card and 4 diagnostic cards for easy troubleshooting of the 5300A, Accessory 10548A. Price: $90.

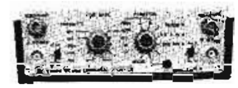
Rack mount kit: a rack mount is available, part number: 10573A single, 10574A double. Price: $35.

Leather carrying case: holds 5300A, snap-on module, and the 5310A battery pack. Accessory 18019A. Price: $25.

Dimensions (with snap-on module): height, 3½" (89 mm), width, 6¼" (160 mm), depth, 9¾" (248 mm).

Price: $395.

5301A



5302A

5301A 10 MHz Frequency Counter Module

Input channel

Range: 10 Hz to 10 MHz.

Sensitivity (min): 25 mV rms sine wave 50 Hz to 1 MHz. 50 mV rms sine wave 10 Hz to 10 MHz; 150 mV p-p pulse at minimum pulse width, 50 ns. Sensitivity variable to 2.5 V rms.

Impedance: 1 MΩ shunted by less than 30 pF.

Overload protection: 500 V (dc + peak ac). 250 V rms, dc to 400 Hz. 10 V rms at 10 MHz.

Trigger level: selectable positive, negative, or zero volts.

Frequency measurement

Range: 10 Hz to 10 MHz.

Gate times: manually selected 0.1, 1, or 10 seconds. AUTO position selects gate time to 1 second for maximum resolution.

Accuracy: ±1 count ± time base accuracy.

Open/close (totalizing)

Range: 10 MHz max.

External gate: gate signal by contact closure to ground or TTL low.

General

Check: counts internal 10 MHz reference frequency.

Operating temperature: 0° to 50°C.

Power requirements: including 5300A mainframe, nominally 8 watts.

Weight: net, 2 lbs (0,9 kg); shipping, 3¼ lbs (1,5 kg).

Dimensions: see 5300A Mainframe.

Price: $145.

Specifications, 10533A Recorder Interface

The 10533A accessory provides an interface between the 5300A measurement system mainframe and a standard parallel-input recorder such as the HP 5055A. The interface module provides conversion from the 5300A serial data output to a standard parallel format.

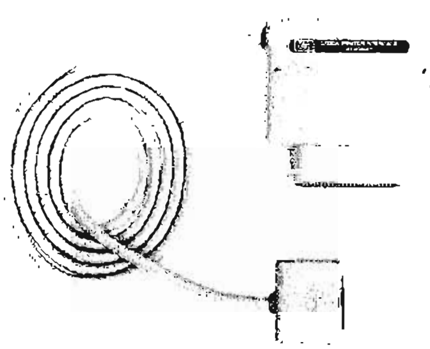
Output format: 10 parallel digits; 6 data, 1 decimal point, 1 overflow, 1 exponent and 1 exponent sign.

Code: 4-line 1-2-4-8 BCD; "1" state low, TTL levels.

Decimal point: floating decimal point automatically inserted at correct digit position. Coded "1111", ("*" on standard HP 5055A print wheels). Internal jumper wire removes decimal point from data format if desired.

Overflow: coded "1111" ("*") printed in first printer column when 5300A overflow light is on.

Exponent: ±0, ±3, ±6 corresponding with 5300A measurement units.



10533A Recorder Interface

Print command: negative step, TTL levels.

Inhibit input: +2.0 V or higher prevents the 5300A from recycling.

Power requirements: 100 mA at 5 volts, provided by 5300A mainframe.

Price: $150.

5302A 50 MHz Universal Counter Module

Input channels A and B

Range: channel A: 10 Hz to 50 MHz; channel B, 10 Hz to 10 MHz.

Sensitivity (min): 25 mV rms sine wave 50 Hz to 1 MHz. 50 mV rms sine wave 10 Hz to 10 MHz. 100 mV rms sine wave at 50 MHz. 150 mV p-p pulse at minimum pulse width, 50 ns. Sensitivity variable to 2.5 V rms.

Impedance: 1 MΩ shunted by less than 30 pF.

Overload protection: 500 V (dc + peak ac). 250 V rms, dc to 400 Hz, 10 V rms above 10 MHz.

Trigger level: selectable positive, negative, or zero volts.

Slope: automatically switched to trigger on positive slope for positive pulse and negative slope for negative pulse. Positive slope for sinusoidal inputs.

Marker outputs: rear panel BNC. TTL low level while gate is open.

Frequency

Range: channel A: 10 Hz to 50 MHz, prescaled by 10: channel B: 10 Hz to 10 MHz.

Gate times: manually selected 0.1, 1, or 10 seconds. AUTO position selects gate time to 1 second for maximum resolution.

Accuracy: ±1 count ± time base accuracy.

Time interval

Range: 500 nsec to 1000 seconds.

Input: channels A and B.

Resolution: 100 ns to 1 ms in decade steps.

Accuracy: ±1 count ± time base accuracy ± trigger error.*

Period

Range: 10 Hz to 1 MHz.

Input: channel B.

Resolution: 100 ns to 1 ms in decade steps.

Accuracy: ±1 count ± time base accuracy ± trigger error.**

Period average

Range: 10 Hz to 1 MHz.

Input: channel B.

Periods averaged: 1 to 10^3 automatically selected.

Frequency counted: 10 MHz.

Accuracy: ±1 count ± time base accuracy ± trigger error.**

Ratio

Display: F_B/F_A times multiplier (N). N=10 to 10^7, selectable in decade steps.

Range: channel A: 10 Hz to 1 MHz. Channel B: 10 Hz to 10 MHz.

Accuracy: ±1 count of F_B ± trigger error or F_A.*

Open/close (totalizing)

Range: 10 MHz max.

Input: channel B opening and closing of gate initiated by front panel pushbutton switch.

General

Check: counts internal 10 MHz reference frequency.

Operating temperature: 0° to 50°C.

Power requirements: including 5300A mainframe, nominally 10 watts.

Weight: net, 2 lbs (0,9 kg); shipping, 3¼ lbs (1,5 kg).

Dimensions: see 5300A Mainframe.

Price: $275.

NEW

5303B

5304A

5303B Frequency counter module

Input channel A (CW or burst)

Range: DC to 525 MHz, prescaled by 8.

Sensitivity: (fixed):
100 mV rms sine wave, dc to 500 MHz
125 mV rms sine wave, 500 MHz to 525 MHz
Signal must pass through zero.

Impedance: 50Ω.

Overload protection: 5 V rms (input circuitry fuse protected).

Input Channel B (CW or burst)

Range: 50 Hz to 80 MHz, direct.

Sensitivity (automatic):
25 mV rms sine wave, 100 Hz to 50 MHz
50 mV rms sine wave, 50 Hz to 100 Hz and 50 MHz to 80 MHz
Sensitivity is adjusted automatically by AGC (automatic gain control). Effective up to input clipping level of 10 V p-p.

Impedance: 1 MΩ shunted by less than 40 pF.

Overload protection: 250 V rms, 50 Hz to 10 KHz declining to 10 V rms above 10 MHz.

Frequency measurement

Resolution: (selectable): 1, 10, 100, 1000 Hz.

Accuracy: ±1 digit ± time base accuracy.

General

Check: counts internal 10 MHz reference frequency.

Overflow: light indicates display exceeded.

Operating temperature: 0° to 50°C.

Power requirements: including 5300A mainframe, nominally 10 watts.

Weight: Net, 2 lbs (0,9 kg). Shipping, 3¼ lbs (1,5 kg).

Dimensions: see 5300A Mainframe.

Price: $800.00.

Option 001: High stability time base.

Frequency: 10 MHz.

Stability: aging rate: <1.2 part in 10^6/year.
temperature: <±5 parts in 10^7, 0° to 50°C.
line voltage: <±5 parts in 10^8 for 10% line variation.

Oscillator output: 10 MHz, approximately 1 V rms at rear panel BNC, 200Ω source impedance.

External input: 1 to 10 MHz, 1 V rms into 500Ω.

Price: $175.00.

Specifications, 5304A Timer/Counter Module

Input Channels A and B

Range: dc coupled; 0 to 10 MHz. AC coupled; 100 Hz to 10 MHz.

Sensitivity (min): 25 mV rms sine wave to 1 MHz. 50 mV rms sine wave to 10 MHz. 150 mV p-p pulse at minimum pulse width, 40 nsec. Sensitivity can be decreased by 10 or 100 times using ATTENUATOR switch.

Impedance: 1 MΩ shunted by less than 30 pF.

Overload protection: 250 V rms on X10 and X100 attenuator settings. On X1 attenuator setting 120 V rms up to 1 kHz, decreasing to 10 V rms at 10 MHz.

Trigger level: PRESET position centers triggering about 0 volts, or continuously variable over the range of −1 V to +1 V times attenuator setting.

Slope: independent selection of triggering on positive or negative slope.

Channel inputs: common or separate lines.

Gate output: rear panel BNC. TTL low level while gate is open.

Time interval

Range: 500 ns to 10^4 sec.

Input: channels A and B; can be common or separate.

Resolution: 100 ns to 10 ms in decade steps.

Accuracy: ±1 count ± time base accuracy ± trigger error.*

Time interval holdoff: front panel concentric knob which inserts variable delay of approximately 100 μs to 100 ms between START (channel A) and enabling of STOP (channel B); may be disabled. Electrical inputs during delay time are ignored. Delay may be digitally measured in CHECK and TIME INTERVAL positions. Delay output: rear panel BNC. TTL low level during delay time.

Period average

Range: 10 Hz to 1 MHz.

Input: channel A.

Period averaged: 1 to 10^3 automatically selected.

Frequency counted: 10 MHz.

Accuracy: ±1 count ± time base accuracy ± trigger error.**

Frequency

Range: 0 to 10 MHz.

Input: channel A.

Gate times: manually selected 0.1, 1, or 10 seconds. AUTO position selects gate time to 1 second for maximum resolution.

Accuracy: ±1 count ± time base accuracy.

Open/close (totalizing)

Range: 10 MHz max.

Input: channel A. Opening and closing of gate initiated by front panel pushbutton switch.

General

Check: inserts internal 10 MHz reference frequency into channels A and B.

Operating temperature: 0° to 50°C.

Power requirements: including 5300A mainframe, nominally 10 watts.

Dimensions: see 5300A mainframe.

Weight: net, 2 lbs (0,9 kg); shipping, 3¼ lbs (1,5 kg).

Price: $325.

* For any waveshape, trigger error is less than ± $\left(\frac{0.005\ \mu s}{\text{Signal Slope (V/}\mu s)}\right)$

** Trigger error is less than ±0.3% of one period ÷ periods averaged for signals with 40 dB or better signal-to-noise ratio.

5310A Battery Pack

18019A Carrying Case

Specifications, 5310A battery pack module

(Provides battery power from rechargeable nickel-cadmium cells)

Battery capacity: 48 watt-hours, nominal. Minimum 3, typically 5 hours of continuous operation at charging and operating temperature (20° to 30°C).

Recharging time: typically 18 hours.

Battery voltage: 12 V dc.

Low voltage indicator: light begins to glow at approximately 90% discharge.

Line failure protection: allows instrument to be operated in LINE position with automatic switch-over to battery power if line voltage fails. Batteries receive trickle charge in LINE position.

Operating temperature: operating: 0° to 50°C. Charging: 0° to 40°C, mainframe not operating.

Power requirements: charging power via 5300A mainframe, nominal 7.5 watts.

Weight: net, 5 lbs (2,3 kg); shipping, 6¼ lbs (2,9 kg).

Accessories furnished: shoulder carrying strap.

Dimensions: battery pack plugs between 5300A mainframe and snap-on module. Increases height of instrument by 1.5 in (38.4 mm).

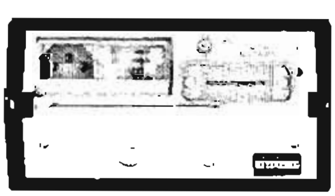
Price: $195.00.

18019A Carrying Case

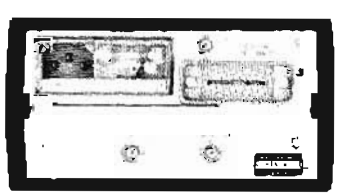
This leather carrying case protects the 5300A during transit. It holds the mainframe and a functional module, with the battery pack inserted between them. The side pocket conveniently stores cables, leads, probes, or connectors to be used with the 5300A System.

Price: 18019A, $25.00.

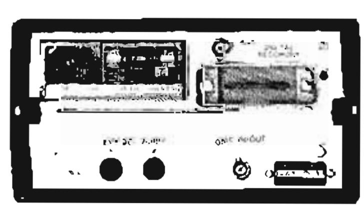
Rear Panels



5300A/5301A

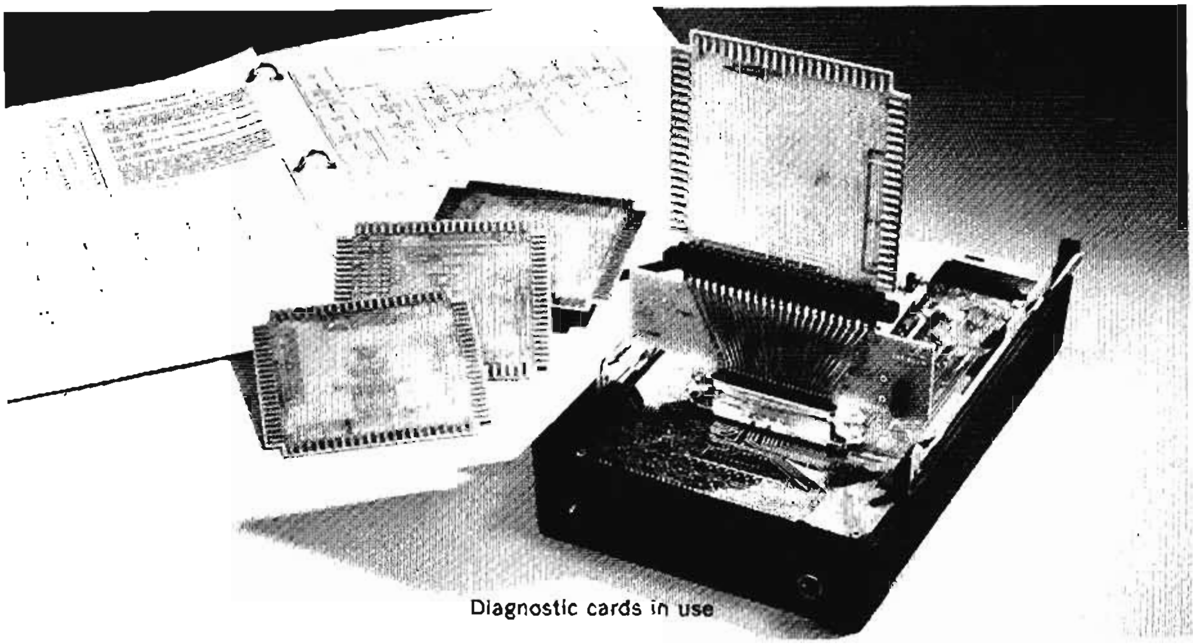


5300A/5302A, 5304A*



5300A/5303B, Opt. 001

*No delay output on rear of 5302A.



Diagnostic cards in use

Optional service support package

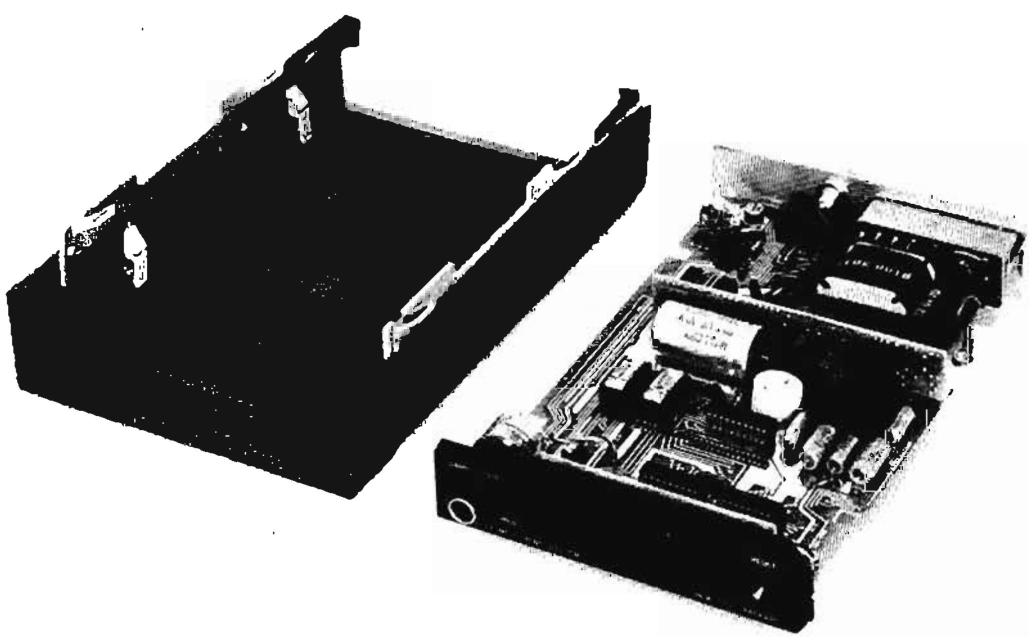
The unique HP 10547A Service Kit provides an efficient means to rapidly troubleshoot and repair the 5300A. It's proven to be both a time and money saver. The kit contains

- an interface card and 4 diagnostic cards for easy troubleshooting of the 5300A
- a spare power supply board
- other miscellaneous spare parts for the 5300A, including replacements for all five major IC's

The four diagnostic cards, shown in use above, contain 16 tests that locate problems to component level. A complete diagnostic flow chart in the 5300A manual provides the step by step troubleshooting procedure.

When the diagnosis of the 5300A is complete, repair of the instrument is simple. All components are easily accessible merely by removing a single screw and snapping out the main PC board.

Price: 10547A, $250.00; 10548A, $90.00 (interface card and 4 diagnostic cards only).

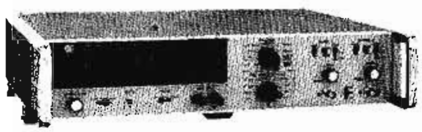


5300A components are accessible in about 15 seconds

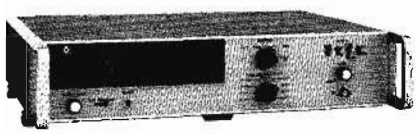
UNIVERSAL COUNTERS
Unique Capabilities in 50 & 550 MHz Counters
5326/5327 Family

50 MHz Universal Timers/Counters/DVMs

5326A

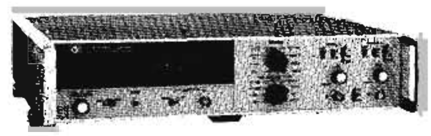


5326B



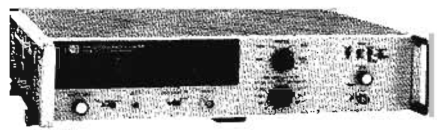
5326C

550 MHz Universal Timers/Counters DVMs



5327A

5327B



5327C

Measurement features

The Hewlett-Packard 5326/5327 family offers versatile, high precision counters to measure frequency, time intervals, or voltage. With six models to choose from, you can select just the capability to solve your own measurement problems without paying for extras. Each model of the 5326/5327 family provides the following features to make your measurements simpler, easier to set up, and more accurate:

Burst and CW frequency measurement—special gating circuits start a count only when your input signal is present. You can measure a frequency burst as easily as a CW signal.

Period average measurement—to give you period information directly; or to give you faster measurements at increased resolution and accuracy on low frequency signals.

Totalize, scale, ratio, multiple ratio—extra problem solving power for your special requirements.

Systems options—select remote programming and digital output to suit your application.

High sensitivity input channels (all models except 5326C) accept low-level signals down to 5 mV to 50 MHz. On the 5327 series the 550 MHz counting circuits provide sensitivity of 25 mV to 550 MHz.

Optional time bases—can give you even greater precision and accuracy.

Front Panel Trigger Lights on the counters show clearly when the counter is triggering properly on the input signal.

Blanking makes your results easier to read by suppressing unwanted leading zeros.

In addition, the 5327 series of 550 MHz counters gives unique fused input protection against damage from accidental overloads.

Time interval measurements

To solve a wide range of time interval measurement problems the 5326/5327 family offers:

One shot time interval measurements from 0.1 μsec to 10^8 sec.

Time interval averaging with resolution better than 100 ps for intervals as short as 150 ps.

Hysteresis compensation to make setup easier, quicker.

For one shot measurements, resolution is selectable from 0.1 μsec to 10 seconds. However, for intervals as short as 150 ps, time interval averaging yields a dramatic increase in accuracy, with resolution up to a thousand times better than for single shot measurements.

Unique high speed synchronizers provide the key to Hewlett-Packard's exclusive time interval averaging capability. The synchronizers set up a very accurate statistical average for up to 10^8 time intervals; resolution improves in proportion to the square root of the number of intervals averaged. To maintain accurate and reliable results, the synchronizers also lock out false measurements such as negative time intervals (stop occurs before start).

Time interval averaging may be used whenever the time interval is repetitive, whether at a uniformly periodic or a completely random rate, provided the input signal repetition rate is not harmonic with the 10 MHz clock. This condition is easily met for many potential applications of time interval averaging. Such applications include measurements of logic timing and propogation delays where time intervals are well below the range of conventional one-shot counter techniques.

Hysteresis compensation, exclusive with Hewlett-Packard, means you only have to set trigger levels once for both positive going and negative going triggering. Most counters have fixed hysteresis bands for a given trigger level setting. So the actual trigger point changes from one edge of the hysteresis band to the other when you change the trigger slope. But with the entire 5326/5327 family, the actual trigger level stays constant when you change slope, because the hysteresis band offsets to compensate. You save a step in setting trigger levels and eliminate a common source of error.

The internal DVM

Both the 5326B and the 5327B include an internal DVM. The DVM gives the user two major benefits. The first benefit is more accurate and far more convenient setting of trigger levels for time interval measurements. The second benefit is substantially increased single instrument capability, especially for systems applications.

With the internal DVM, you can actually set trigger levels with digital accuracy. The unique functions READ A and READ B monitor the internal trigger level settings for the A and B channels. The values are shown directly on the display. This method has been found far superior to conventional marker techniques using Z-axis modulation on a scope. The DVM makes it possible to accurately set up time interval measurements such as pulse width between the 50% levels.

Of course, the integrating DVM also can make accurate external voltage measurements. Thus a single instrument can do the job of two. For systems applications, this means there is only one instrument to program and a single set of outputs for all measurements.

High stability time bases

The standard time base for the 5326/5327 family uses a stable 10 MHz crystal oscillator. This room temperature crystal provides fast warm-up, with a long term aging rate of less than 3 parts in 10^7 per month.

Two higher stability time bases are available as options. Both optional time bases meet FCC specifications for checking base station transmitters. Option 010, a temperature compensated crystal oscillator, provides significantly improved temperature stability, as well as an improved aging rate of 1 part in 10^7 per month. For the many applications requiring even greater stability, Option 011 provides a proportional oven controlled crystal oscillator that gives exceptionally good temperature stability and a long term aging rate of less than 5 parts in 10^{10} per day. The 5327C with Option 011 is **FCC type approved** for broadcast services.

A summary of the time base option specifications appears on the bottom of the page.

Systems compatibility

Each member of the 5326/5327 family can be effectively used as a fast, efficient systems instrument.

Option 003 provides 4-line 1-2-4-8 BCD output with "1" state positive. This output is suitable for systems use or for output devices such as the HP Model 5050B or 5055A Digital Recorders or the 3489A Data Punch.

Option 002 (all models) and Option 004 (5326A/B and 5327A/B only) provide remote programming capability via contact closure to ground or DTL drive. A rear panel connector provides access to all programmable circuits. With Option 002 all front panel controls are single line programmable except the FAST/NORM MODE, SEPARATE-COMMON switch (the CHECK position is programmable on the 5326A/B and 5327A/B only), input attenuators, and ac-dc input coupling switches. With Option 004 all front panel controls including all signal input conditioning are single line programmable except the FAST/NORM MODE. Both Options 002 and 004 provide programmable trigger level controls through single line analog signals.

In addition, the HP 10542A Remote Programming Interface provides two digital-to-analog converters to enable the 5326/5327 series with Option 004 to be completely programmed from a standard 40-bit digital output register for the HP 2100 series computers.

5326/5327 Family selection

Model	Description	Frequency Range	Period Average Totalize/Ratio Scaling	Time Interval Time Interval Averaging	DVM (DC Voltage)	Price
5326C	Multi-Function Counter	50 MHz	■			$ 950
5326A	Universal Timer/Counter	50 MHz	■	■		1,250
5326B	Universal Timer/Counter/DVM	50 MHz	■	■	■	1,595
5327C	Multi-Function Counter	550 MHz	▨			1,525
5327A	Universal Timer/Counter	550 MHz	▨	▨		1,850
5327B	Universal Timer/Counter/DVM	550 MHz	▨	▨	▨	2,195

5326/5327 specifications

Display: 7 digits (8 optional).

Blanking: suppresses display of unwanted zeros left of the most significant digit.

Display storage: holds reading between samples. Rear panel switch overrides storage.

Sample rate: FAST and NORM ranges, and HOLD position.

Overflow: neon indicates when display range is exceeded.

Operating temperature: 0° to 50°C (see DVM Temp. Range).

Gate output: TTL level pulses, low while gate open, rear panel.

Power requirements: 115/230 V ±10%, 50/60 Hz, 70 watts (max).

Weight: max: net, 16 lbs (7.4 kg); shipping, 18 lbs 16 oz (8.7 kg).

Dimensions: 3-15/32" high x 16¾" wide x 11¼" deep (88.2 x 425 x 286 mm).

Accessories furnished: 7½ ft power cord; rack mount kit.

Accessories available

HP 10503A: 50Ω BNC cable, 4 ft (122 cm). Price, $13.

HP 10542A: remote programming interface enables interfacing between the 5326/5327 series counters with Option 004 and a 40-bit output register. Includes two (2) 7 bit digital-to-analog converters for level controls and decoding for time base and function selector. Price, $500.

HP Cable 562A-16C: (6 ft, 183 cm) to connect 5326/5327 series with Option 003 to HP 5050B Digital Recorder. Price, $50.

Option 001: 8-digit display. Price, $75.

Option 002: remote programming. All front panel controls are single line programmable except:

SEP-COM switch; CHECK is programmable (5326A/B, 5327A/B only) FAST/NORM mode.

Input attenuators.

AC/DC input signal coupling.

Price: $75.

Option 003: digital output (for numerals and polarity only).

Price: $50.

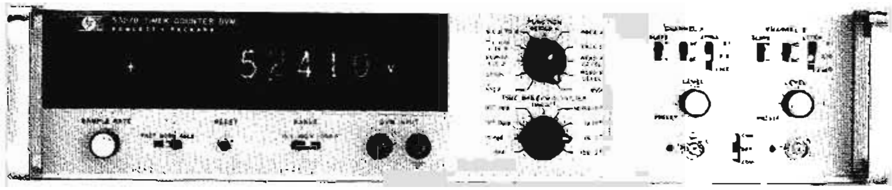
Option 004: remote programming including all signal input conditions (includes attenuators and ac/dc switches). All front panel controls are programmable except FAST/NORM mode.

Price: $200.

High stability time base options

Option	Aging Rate	Short Term Stability	Temperature Stability	Price
Standard	<3 x 10^{-7}/mo	<5 x 10^{-9}/1 sec rms (typ)	<=2.5 x 10^{-6}, 0° to 50°C	included
Option 010	<1 x 10^{-7}/mo	<1 x 10^{-9}/1 sec rms (typ)	<=5 x 10^{-7}, 0° to 50°C	$150
Option 011	<5 x 10^{-10}/day	<1 x 10^{-11}/1 sec rms	<3 x 10^{-9}, 0° to 50°C	350

550 MHz Universal Timer/Counter/DVM



5327B

5326B and 5327B Specifications

Input Channels A and B

Range: dc-coupled: 0-50 MHz; ac-coupled: 20 Hz-50 MHz.

Sensitivity (min): 0.1 V rms sine wave; 0.3 V p-p pulse; 8 ns minimum pulse width. Sensitivity can be decreased by 10 or 100 times, using the ATTENUATOR switch.

Impedance: 1 MΩ shunted by less than 25 pF.

Dynamic input voltage range: 0.1 to 3 V rms ac times attenuator setting. ±5 V dc times attenuator setting.

Trigger level: PRESET to center triggering about 0 V or variable over the range of −3 V to +3 V times attenuator setting. Trigger threshold band <1.0 mV, referred to input at maximum frequency.

Overload protection: 250 V rms on all attenuator settings, except 25 V rms on X1 above 50 kHz.

Slope: independent selection of positive or negative slope.

Channel inputs: common or separate lines.

Marker outputs: rear panel BNC's. DTL pulse, low for approx 2 μs after trigger point for A and B channels.

Input Channel C and C÷10

Range: 5326B: Channel C: dc-coupled; 0-50 MHz. 5327B: Channel C: ac-coupled; 1 kHz-50 MHz; C÷10 (prescale); 0-550 MHz.

Sensitivity: 5326B: Channel C: 5 mV rms. 5327B: Channel C: 5 mV rms; C÷10 (prescale); 25 mV rms.

Impedance: 50Ω nominal.

Maximum input: 3.5 volts rms; 5.0 volts peak.

Trigger level: 0 volts.

Location: rear panel.

Start
(Totalizing and Scaling)

Range: 0-10 MHz.

Factor: $1\text{-}10^{8}$ selectable in decade steps.

Output: rear panel TIME BASE BNC.

Display: Channel A input divided by scaling factor.

* ±10 counts of input frequency. (±1 count displayed.)

** For any wave shape, trigger error is less than $\pm \frac{0.0025}{\text{Signal Slope (V}/\mu\text{s)}}\ \mu s$

Frequency

Range: 5326B: 0-50 MHz. 5327B: 0-50 MHz (direct); 0-550 MHz (prescaled).

Input: 5326B: Channel A or Channel C (switchable). Channel A provides triggered frequency measurement. 5327B: Channel A; Channel C for direct and C÷10 for prescaled (switchable). Channel A provides triggered frequency measurement.

Gate times: 0.1 μs to 10 s in decade steps.

Accuracy: direct: ±1 count ± time base accuracy. Prescaled: ±10 counts* ± time base accuracy.

Display: MHz, kHz, or GHz with positioned decimal point.

Time interval

Range: 0.1 μs to 10^{8} seconds.

Input: Channels A and B; can be common or separate.

Frequency counted: 10 MHz to 0.1 Hz in decade steps.

Accuracy: ±1 count ± time base accuracy ± trigger error.**

Display: μs, ms, seconds or 10's of seconds with positioned decimal point.

Time interval average

Range: 0.15 ns to 10 s.

Intervals averaged: $1\text{-}10^{8}$ selectable in decade steps.

Input: Channels A and B; can be common or separate.

Frequency counted: 10 MHz.

Accuracy: $\pm \text{ time base accuracy } \pm 2 \text{ ns} \pm \frac{(\text{trigger error}^{**} \pm 100 \text{ ns})}{\sqrt{\text{intervals averaged}}}$

Display: ns, μs with positioned decimal point.

Period

Range: 0-10 MHz.

Input: Channel A.

Frequency counted: 10 MHz to 0.1 Hz in decade steps.

Accuracy: ±1 count ± time base accuracy ± trigger error.***

Display: μs, ms, seconds or 10's of seconds with positioned decimal point.

*** Trigger error is less than ±0.3% of one period ÷ periods averaged for signals with 40 dBm or better signal-to-noise ratio and 100 mV rms amplitude.

Period average

Range: 0-10 MHz.
Periods averaged: 1-10^8 selectable in decade steps.
Input: Channel A.
Frequency counted: 10 MHz.
Accuracy: ±1 count ± time base accuracy ± trigger error.*** (See footnote, page 224.)
Display: ns, μs with positioned decimal point.

Ratio

Display: any input function/F_{ext} times Multiplier (M). M = 1 to 10^8 (10-10^9 when prescaling) selectable in decade steps.
Range: any input function. See appropriate function section.
F_{ext}: (External Oscillator Input) 100 Hz-10 MHz.
Mode: any input function.
Accuracy: accuracy of selected input function ± trigger error of F_{ext}.

Integrating Digital Voltmeter (5326B and 5327B *only*)

The unique combination of an integrating digital voltmeter and an electronic timer/counter produces an instrument which can do much more than can be done with a separate counter and a separate DVM. The mainframe DVM in the 5326B and 5327B easily measures ± dc levels in three programmable ranges from ±10 V to ±1000 V. Plus, the DVM can internally measure and set the start and stop time interval trigger point levels. This feature, together with hysteresis compensation, gives the 5326B and 5327B the easiest and most accurate trigger level setting system available with none of the drawbacks of oscilloscope marker techniques. The DVM measurement (integration) time is selectable from 1 ms to 10 sec to permit a trade-off of resolution vs. measurement time.

The heart of the integrating digital voltmeter in the 5326/5327 is the very stable voltage-to-frequency converter.

Using this converter, one obtains a very stable linear digital voltmeter with high resolution and excellent accuracy. This DVM can also measure high frequency ac voltages using the HP 11096 ac probe for voltages of 0.25 V to 30 V rms with ±5% accuracy and with 4 MΩ/2 pF input impedance. The frequency range is 100 kHz to 500 MHz. The combination of an integrating digital voltmeter with a timer/counter greatly expands the capabilities of both instruments. Thus the user of the 5326B or the 5327B Timer/Counter/DVM has a digital measurement system of unequaled capability at a moderate cost.

Technique: voltage-to-frequency conversion.
Voltage ranges: manual selection.

RANGE (V dc)	RESOLUTION (1 sec, integration time)	INPUT IMPEDANCE
10	100 μV	10 MΩ
100	1 mV	10 MΩ
1000	10 mV	10 MΩ

Input: single ended.
Polarity: automatic polarity detection.
Overrange: 25% overrange on 10 V and 100 V ranges with full accuracy.
Overload protection: 1100 V dc all ranges.
Accuracy: after 10 minutes warm-up (within 90-day calibration period).

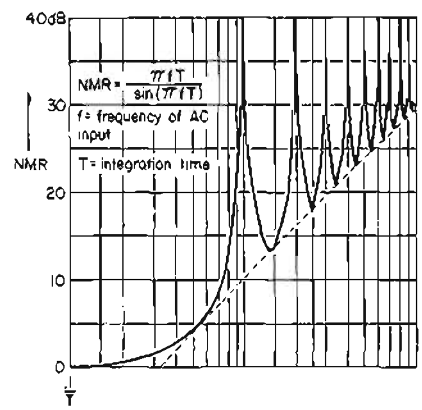
Range	Stability	Linearity	Zero Drift	Counter
	(% of Reading)	(% of Range)	(% of Range)	
10 V	±0.04%	±0.01	±0.01%	±1 count
100 V	±0.04%	±0.01%	±0.01%	±1 count
1000 V	±0.08%	±0.01%	±0.01%	±1 count

Operating temperature: 10°C to 40°C, <80% RH.

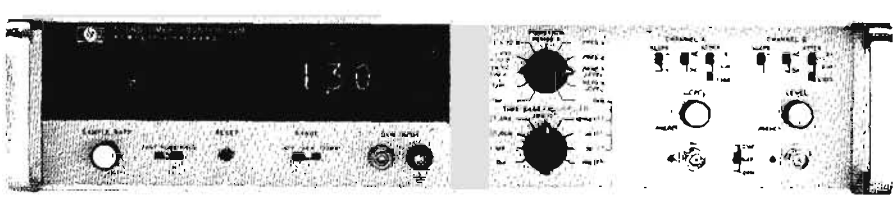
Measurement time

1 msec	2 digits	
10 msec	3 digits	Decimal points automatically displayed
100 msec	4 digits	
1 sec	5 digits	
10 sec	6 digits	

Response time: <100 μs for full accuracy with a step function point.
AC noise rejection: infinite for multiples of (measurement time)$^{-1}$. See graph for Normal Mode Rejection.

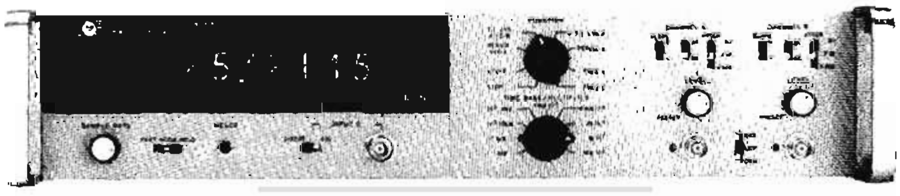


50 MHz Universal Timer/Counter/DVM



5326B

550 MHz Universal Timer/Counter



5327A

5326A And 5327A Specifications

Input Channels A and B

Range: dc-coupled: 0-50 MHz. ac-coupled: 20 Hz-50 MHz.
Sensitivity (min): 0.1 V rms sine wave. 0.3 V p-p pulse. 8 ns minimum pulse width.
Sensitivity can be decreased by 10 or 100 times, using the ATTENUATOR switch.
Impedance: 1 MΩ shunted by less than 25 pF.
Dynamic input voltage range: 0.1 to 3 V rms ac times attenuator setting. ±5 V dc times attenuator setting.
Trigger level: PRESET to center triggering about 0 V or variable over the range of −3 V to +3 V times attenuator setting. Trigger threshold band <1.0 mV, referred to input at maximum frequency.
Overload protection: 250 V rms on all attenuator settings, except 25 V rms on X1 above 50 kHz.
Slope: independent selection of positive or negative slope.
Channel inputs: common or separate lines.
Marker outputs: rear panel BNC's. DTL pulse, low for approx 2 μs after trigger point for A and B channels.

Input Channel C and C÷10

Range: 5326A. Channel C: dc-coupled; 0-50 MHz. 5327A: Channel C: ac-coupled; 1 kHz-50 MHz; C÷10 (prescale); 0-550 MHz.
Sensitivity: 5326A: Channel C: 5 mV rms. 5327A: Channel C· 5 mV rms; C÷10 (precale)· 25 mV rms.
Impedance: 50Ω nominal.
Maximum input: 3.5 volts rms; 5.0 volts peak.
Trigger level: 0 volts.

Start

(Totalizing and Scaling)

Range: 0-10 MHz.
Factor: 1-10^8 selectable in decade steps.
Output: rear panel TIME BASE BNC.
Display: Channel A input divided by scaling factor.

Frequency

Range: 5326A: 0-50 MHz. 5327A: 0-50 MHz (direct); 0-550 MHz (prescaled).
Input: 5326A: Channel A or Channel C (switchable). Channel A provides triggered frequency measurement. 5327A: Channel A; Channel C for direct and C÷10 for prescaled (switchable) Channel A provides triggered frequency measurement.
Gate times: 0.1 μs to 10 s in decade steps.
Accuracy: direct: ±1 count ± time base accuracy. Prescaled: ±10 counts* ± time base accuracy.
Display: MHz, kHz, or GHz with positioned decimal point.

Time Interval

Range: 0.1 μs to 10^8 seconds.
Input: channels A and B; can be common or separate.
Frequency counted: 10 MHz to 0.1 Hz in decade steps.
Accuracy: ±1 count ± time base accuracy ± trigger error.**
Display: μs, ms, seconds or 10's of seconds with positioned decimal point.

Time Interval average

Range: 0.15 ns to 10 s.
Intervals averaged: 1-10^5 selectable in decade steps.
Input: channels A and B; can be common or separate.
Frequency counted: 10 MHz.
Accuracy: $\pm$ time base accuracy ± 2 ns $\pm \dfrac{(\text{trigger error}^{**} \pm 100 \text{ ns})}{\sqrt{\text{intervals averaged}}}$
Display: ns, μs with positioned decimal point.

Period and Period average

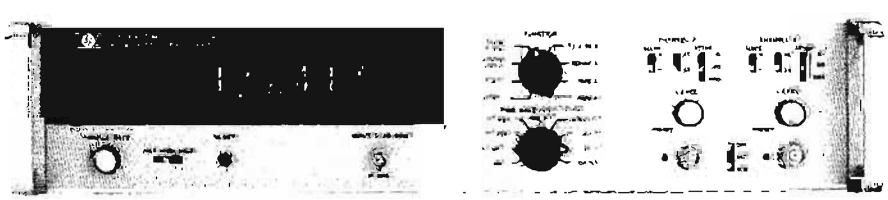
Range: 0-10 MHz.
Input: Channel A.
Frequency counted: 10 MHz to 0.1 Hz in decade steps for period. 10 MHz for Period Average.
Periods averaged: 1-10^5 selectable in decade steps.
Accuracy: ±1 count ± time base accuracy ± trigger error.***
Display: ns, μs, ms. seconds or 10's of seconds with positioned decimal point.

Ratio

Display: any input function/F_{ext} times Multiplier (M). M = 1 to 10^5 ($10\text{-}10^9$ when prescaling) selectable in decade steps.
Range: any input function. See appropriate function section. F_{ext}: (External Oscillator Input) 100 Hz-10 MHz.
Mode: any input function.
Accuracy: accuracy of selected input function ± trigger error of F_{ext}.

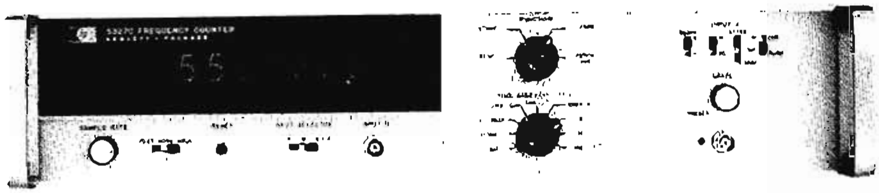
*, **, ***, —see p. 269 for footnotes

50 MHz Universal Timer/Counter



5326A

550 MHz Multi-Function Counter



5327C

5326C And 5327C Specifications

Input Channel A

Range: dc-coupled: 0-50 MHz; ac-coupled: 20 Hz-50 MHz.
Sensitivity (min): 0.1 V rms sine wave; 0.3 V p-p pulse; 8 ns minimum pulse width.
Sensitivity can be decreased by 10 or 100 times, using the ATTENUATOR switch.
Impedance: 1 MΩ shunted by less than 25 pF.
Dynamic input voltage range: 0.1 to 3 V rms ac times attenuator setting. ±5 V dc times attenuator setting.
Trigger level: PRESET to center triggering about 0 V or variable over the range of −3 V to +3 V times attenuator setting. Trigger threshold band <1.0 mV, referred to input at maximum frequency.
Overload protection: 250 V rms on all attenuator settings, except 25 V rms on X1 above 50 kHz.
Slope: independent selection of positive or negative slope.

Input Channel B and B÷10
(5327C only)

Range: Channel B: ac-coupled, 1 kHz-50 MHz; B÷10: dc-coupled, 0-550 MHz.
Sensitivity: Channel B: 5 mV rms; B÷10 (prescaled): 25 mV rms.
Impedance: 50Ω nominal.
Maximum input: 3.5 volts rms, 6.0 volts peak.
Trigger level: 0 volts.

Start
(Totalizing and Scaling)

Range: 5326C: 0-10 MHz. 5327C: 0-10 MHz (direct); 0-100 MHz (prescaled).
Factor: 5326C: 1-10^8 in decade steps. 5327C: Channel A or Channel B: 1-10^8 in decade steps; B÷10: 10-10^9 (1-10^8 on selector) in decade steps.
Output: rear panel TIME BASE BNC.
Display: Channel A, B, or B÷10 input divided by scaling factor.

Frequency

Range: 5326C: 0-50 MHz. 5327C: 0-50 MHz (direct); 0-550 MHz (prescaled).
Input: 5326C: Channel A. Channel A provides triggered frequency measurement. 5327C: Channel A; Channel B for direct and B÷10 for prescaled (switchable). Any channel provides triggered frequency measurement.
Gate times: 0.1 μs to 10 s in decade steps.
Accuracy: direct: ±1 count ± time base accuracy. Prescaled. ±10 counts* ± time base accuracy.
Display: MHz, kHz or GHz with positioned decimal point.

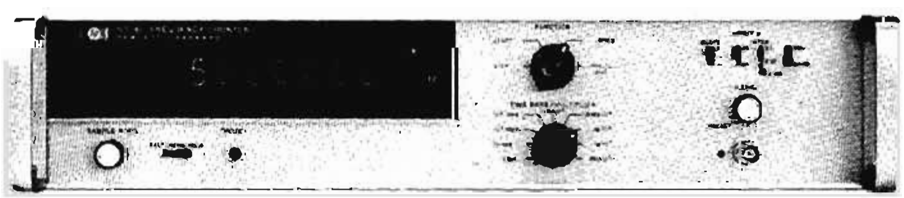
Period average

Range: 5326C: 0-10 MHz. 5327C: 0-50 MHz (direct); 0-550 MHz (prescaled).
Periods averaged: 5326C. 1-10^8 in decade steps. 5327C: Channel A or Channel B: 1-10^8 in decade steps; B÷10: 10-10^9 (1-10^8 on selector) in decade steps.
Frequency counted: 10 MHz.
Accuracy: direct: ±1 count ± time base accuracy ± trigger error.*** Prescaled: ±10 counts* ± time base accuracy ± trigger error.***
Display: ns, μs with positioned decimal point.

Ratio

Display: any input function/F_{ext} times Multiplier (M). M = 1 to 10^8 (10-10^9 when prescaling) selectable in decade steps.
Range: any input function. See appropriate function section. F_{ext}: (External Oscillator Input) 100 Hz-10 MHz.
Mode: any input function.
Accuracy: accuracy of selected input function ± trigger error of F_{ext}.

50 MHz Multi-Function Counter



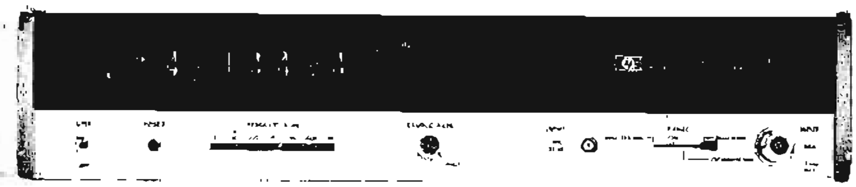
5326C

* ±10 counts of input frequency. (±1 count displayed.)
** For any wave shape, trigger error is less than $\pm \frac{0.0025}{\text{Signal Slope (V/}\mu s)}$ μs
*** Trigger error is less than ±0.3% of one period ÷ periods averaged for signals with 40 dBm or better signal-to-noise ratio and 100 mV rms amplitude.

MICROWAVE FREQ. COUNTER

Automatic, direct readout, 1 Hz to 18 GHz

Model 5340A



5340

NEW

A high performance microwave frequency counter that is:

Simple to use
- single input 10 Hz to 18 GHz
- completely automatic
- auto amplitude discrimination
- fast acquisition time
- direct readout

More flexible
- high sensitivity, −35 dBm
- complete programmability
- wide dynamic range, 42 dB
- superior AM & FM tolerance

More reliable
- high damage level +30 dBm
- high stability oscillator
- no false locking

Introduction

The 5340A Automatic Microwave Counter provides a modern, easily used, more versatile instrument for the direct measurement of frequencies from 10 Hz through 18 GHz via a single input connector. Utilizing new microwave samplers incorporated in advanced phase-lock loops, this new counter excels in virtually every microwave counter specification parameter. It is therefore suited to a wider range of applications than ever before possible for a fully automatic microwave counter.

Single input and high sensitivity

Since one input connector handles all signals from 10 Hz to 18 GHz, instrument use is greatly simplified—particularly in automatic systems or for high speed production test. In the past, several input connectors have been utilized and had to be selected, complicating use. The high sensitivity enhances measurement in the microwave field where signals are low level and many times have to be connected via directional couplers or lossy devices. The sensitivity is such that in some cases signals can be measured directly with only the use of an antenna.

Superior AM characteristics

The high sensitivity and wide dynamic range considerably improves measurement in the presence of audio modulation. As an example, measurement is easily achieved on a 0 dBm signal with greater than 90% AM modulation.

High impedance input

A second input is provided covering the direct measurement range (10 Hz to 250 MHz) of the instrument. This input is useful in the measurement of IF frequencies or signals from higher impedance circuits.

No false answers

The 5340A always provides the proper measurement answer. Measurement and display are disabled until phase-lock or direct measurement are determined, automatically preventing incorrect measurement or displays.

Automatic amplitude discrimination

Automatic amplitude discrimination allows the instrument to choose the largest signal in a spectrum (250 MHz to 18 GHz) and measure only that signal's frequency. Thus, despite the 5340's uniquely high sensitivity and wide bandwidth, the counter will not lock and measure lower level or harmonically-related signals present with the signal of interest.

Superior FM characteristics

This microwave counter is designed to measure carrier frequencies in the presence of wide frequency deviations caused by frequency modulation, phase modulation, or high residual noise. FM tolerance characteristics are a function of modulation rate and carrier frequency, and are described in the graph of Figure 1.

Complete programmability

Simplicity, low profile, light weight, complete programmability, and digital output allow the 5340A Microwave Counter to become a complete and practical component for unattended computer and systems applications. Programming of all front panel controls and the octave range of the phase-lock loop is possible. The octave range programming allows selection of a single band for measurement, reducing acquisition to typically less than 25 ms. These features provide programming of the 5340A and data acquisition via a single input/output slot of most computers. Complete programmability and digital output may be achieved by specifying Option 003. Another valuable option available for systems use provides both signal input connectors on the rear of the instrument (Option 002).

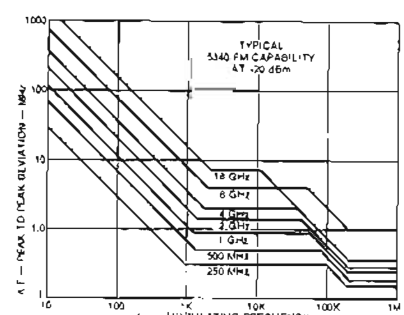


Figure 1. FM Characteristics

Specifications

Signal input

Input 1

Range: 10 Hz to 18 GHz.

Symmetry: sinewave or squarewave input (40% duty factor, worst case).

Sensitivity: −30 dBm, 10 Hz-250 MHz (direct count), −35 dBm, 250 MHz-12.4 GHz: −25 dBm, 12.4-18 GHz.

Dynamic range: 37 dB, 10 Hz-250 MHz, 42 dB, 250 MHz to 12 GHz; 32 dB, 12 GHz to 18 GHz.

Impedance: 50Ω.

VSWR: <2:1, 10 Hz-12.4 GHz; <3:1, 12.4-18 GHz.

Connector: precision Type N.

Coupling: dc to load, ac to instrument.

Damage level: +30 dBm ±7 V dc (total power not to exceed 1 w).

Acquisition time: <150 ms mean typical.

Input 2

Range: 10 Hz-250 MHz direct count.

Sensitivity: 50 mV rms, 150 mV p-p pulses to 0.1% duty factor minimum pulse width 2 nsec.

Impedance: 1 MΩ shunted by <25 pF. Option 002 (rear panel input) 1 MΩ shunted by <100 pF. 50Ω termination (provided for front panel input) required to meet all specifications with Option 002 installed.

Connector: Type BNC female.

Coupling: ac.

Maximum input: 10 Hz to 100 Hz 200 V rms; 100 Hz to 100 kHz 20 V rms; 100 kHz to 250 MHz 2 V rms.

Automatic amplitude discrimination: the counter will automatically select the largest of all signals present (250 MHz to 18 GHz phase-lock range), providing that signal is 20 dB (10 dB typical) larger than any other.

Maximum AM modulation: any modulation index as long as the minimum voltage of the signal is not less than the sensitivity specification. For example, with a −10 dBm input signal at 10 GHz, 94.5% modulation index will cause the signal to drop to −35 dBm (4 mV) at its lowest amplitude and would be the limit of modulation possible.

Time base

Crystal frequency: 10 MHz.

Stability:

Aging rate: $<\pm 3 \times 10^{-7}$ per month.

Short term: $<5 \times 10^{-10}$ rms for 1 second averaging time.

Temperature: $<\pm 2 \times 10^{-6}$ over the range of −20° to +65°C.

Line variation: $<\pm 1 \times 10^{-7}$ for 10% line variation from 110 V or 230 V line.

Output frequency: 10 MHz ≥2.4 V square wave (TTL compatible) available from rear panel BNC.

External time base: requires 10 MHz approximately 1.5 V p-p sine wave or squarewave into 1 KΩ via rear panel BNC. Switch selects either internal or external time base.

Optional time base (Option 001)

Option 001 provides an oven controlled crystal oscillator time base with an aging rate near that of a time standard. This option results in better accuracy and longer periods between calibration. A separate power supply keeps the crystal oven on and up to temperature when the instrument is turned off as long as it remains connected to the power line.

Frequency: 10 MHz.

Aging rate: $<\pm 5 \times 10^{-10}$/day after 24 hour warm-up* and $<1.50 \times 10^{-7}$/year.

Short term stability:

1×10^{-11} for 1 s avg. time.

1×10^{-11} for 10 s avg. time.

2×10^{-11} for 100 s avg. time.

Line variation: $<\pm 5 \times 10^{-10}$ 10% change.**

Temperature: $<\pm 1 \times 10^{-8}$ frequency change over a −55°C to 65°C temperature range. $<\pm 2.5 \times 10^{-9}$ over 0 to 40°C range.

Warmup: within 5×10^{-9} of final*** value 15 minutes after turnon, at 25°C.

Frequency adjustment range: $\pm 2 \times 10^{-6}$ (>±40 Hz from 10 MHz) with 18-turn control.

Frequency adjustment: 1×10^{-9} (0.01 Hz) 18-turn control.

* For oscillator off-time less than 24 hours.

** 1 minute required for unit to stabilize.

*** Final value is defined as frequency 24 hours after turn-on.

General

Accuracy: ±1 count ± time base error.

Resolution:

Front panel switch selects 1 MHz, 100 kHz, 10 kHz, 1 kHz, 100 Hz, 10 Hz, or 1 Hz.

Display:

Eight in-line long life display tubes with positioned decimal point and appropriate measurement units of kHz, MHz, or GHz.

"DIR" lamp indicates measurement is direct.

"LOCK" lamp indicates phase-lock has been achieved and measurement technique is indirect.

"GATE" lamp indicates measurement is in progress.

"RMT" lamp indicates instrument is controlled via external or remote device.

"OVFL" indicates most significant digits will not be displayed. Digits displayed when "OVFL" is lighted are accurate ±1 count ± time base accuracy. "OVFL" is necessary for some high frequency measurements where resolution of 100 Hz is required.

"*" lamp indicates Option 001 crystal oven time base is in the process of warming up (10-15 min. approximately).

Self check: counts and displays 10 MHz for resolution chosen.

Sample rate: controls time between measurements. Continuously adjustable from approximately 200 milliseconds to 5 seconds. HOLD position holds display indefinitely. RESET button resets display to zero and activates a new measurement.

Operating temperature: 0° to 50°C.

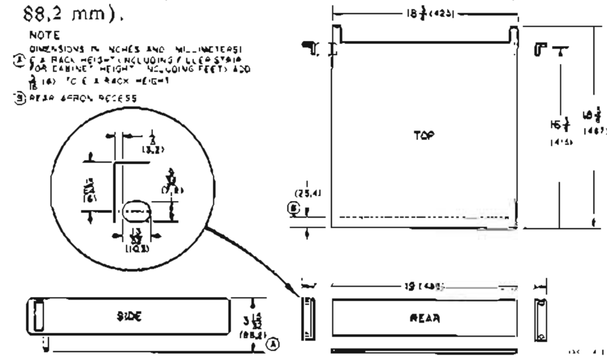
Power: 115 V or 230 V ±10%, 50-60 Hz, APX .100 VA.

Weight:

Net: 25 lb (11,3 kg).

Shipping: 31 lb (14,1 kg).

Dimensions: 16¾" W x 13¼" D x 3-15/32" H (425 x 337 x 88,2 mm).



Accessories furnished: power cord 7½ ft (200 cm), NEMA plug, Rack Mounting Kit

Accessories available:

59310A Interface Kit for use with 5340A Option 003 and Hewlett-Packard computers.

11144A, Option 20 Interface Kit for use with 5340A Option 003 and Model 9820A Calculator.

ASCII (Option 003) to parallel BCD converter K01-5340A.

Rear Panel Connectors (Option 002)

This option provides input connectors on the rear panel. Input specifications remain the same. Input 1 (Type N) is on the rear panel in place of installation on the front panel. Input 2 (BNC) is available on the front and rear panels. Input impedance is reduced to 50Ω.

Remote Programming and Digital Output (Option 003)

Option 003 adds the capability of digital outputting and remote programming via a 24 pin, series 57 microribbon connector on the rear panel marked DIGITAL INPUT/OUTPUT. The TTL and DTL compatible, bi-directional bus consists of eight (8) data lines plus 7 status and control lines. Both program and output information are seven-bit ASCII (USA Standard Code for Information Interchange) characters. They are passed over the data lines on a character-serial basis.

Connector: 24-pin female, Amphenol 57-10240, HP #1251-3283. Mating connector male, Amphenol 57-20240-2, HP #1251-0389.

Price: Model 5340A, $5,300.00.

Option 001: High Stability Time Base, $400.00

Option 002: Rear Panel Connectors, $100.00.

Option 003: Remote Programming-Digital Output, $350.

COMPUTING COUNTER SYSTEM

Precision measurement, computation

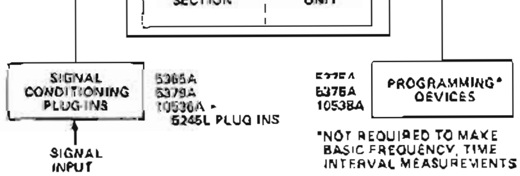
5360 Series

The Computing Counter System . . . Precise, Total Solutions to Complex Problems

The Computing Counter is a general purpose precision digital instrument with built-in arithmetic capability.

As a measuring device the Computing Counter provides unequalled precision. For example, it can measure the time between two events to a resolution of 100 picoseconds, about the time it takes light to travel one inch.

The Computing Counter's unique measurement technique employs extensive use of digital computation. Thus the mainframe contains an arithmetic unit which is an inherent, indispensable part of the measurement cycle.



Basic Block Diagram of Computing Counter. The precision measurement technique employs digital computation as an inherent, indispensable part of the measurement cycle.

Measurement

Measurement versatility is enhanced by a wide range of plug-ins in addition to the input module. All measurements are made with speed and accuracy and in many respects, operation is easier than with the conventional instrument.

Computation

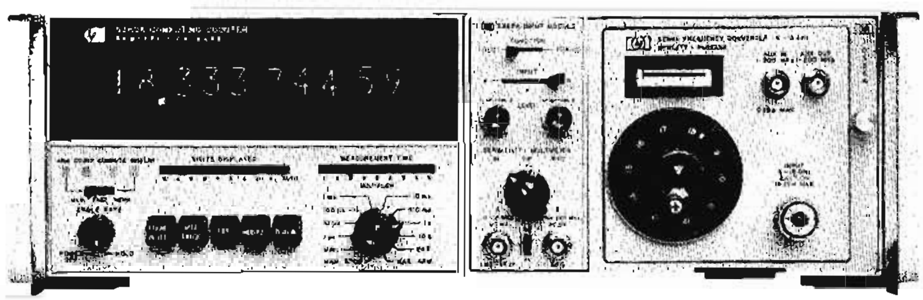
The arithmetic capability of the machine has been made available to the user via several programming devices.

This allows the system to be programmed to solve equations where measurements are the variables, in real time. This capability enormously increases the power of the Computing Counter System.

Note that the programming devices are not needed to obtain the measurement capabilities of the instrument. Inclusion of the appropriate programmer, however, enhances the capabilities of the Computing Counting system in providing precise, total solutions to complex problems at substantial cost saving and ease of operation.

The following two pages introduce the components of the Computing Counter System. Additional details are included in the tutorial (pp. 247-251). A full description of the system is given in the Computing Counter System data sheet. In addition, some of the many applications to which this versatile system can be put are described in the applications literature overpage. All literature is available on request.

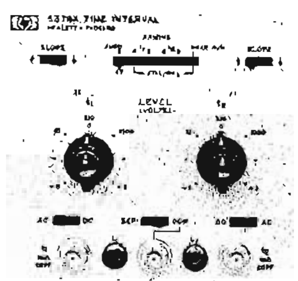
Precision Frequency Measurements
5360A Computing Counter
5365A Input Module
5245 Series Plug-Ins



Features
- 320 MHz direct frequency range
- To 18 GHz with plug-ins
- Most accurate frequency measuring device available
- High speed . . . better than 300 measurements/sec
- External trigger capability enhances versatility
- Automatic display
- High stability time base
- Versatile measurement time controls
- High speed data gathering capability

Measure
- Pulse compression radar
- CW and pulsed, Doppler radar
- Frequency shift keyed (FSK)
- Precision oscillators for fast calibration
- PCM and fsk bit detection
- FM and transient frequencies
- Amplitude and pulse modulated signals

Price: $6500.

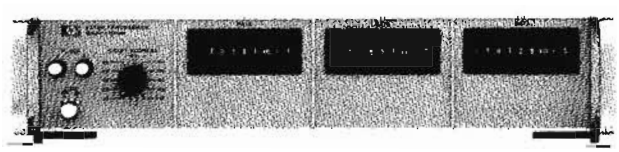


Precision time interval measurements
5379A Time Interval Plug-In

Features
- 100 picosecond displayed resolution
- ±500 picosecond accuracy
- Zero seconds minimum measurable time interval
- Positive or negative time intervals
- High speed, better than 1000 measurements/sec
- Hysteresis compensation of trigger levels
- Versatile arming modes
- Absolute trigger level determination
- 5 picosecond resolution by averaging

Measure
- Laser and radar ranging
- Delay line calibration
- Integrated circuit characterization (rise, fall, delay times)
- Computer checkout
- Nuclear time of flight measurements
- Coincidence detection
- Instrument calibration

Price: $800.



Computation
5376A Systems Programmer

- Automatic operation
- Simple programming
- Precision system measurement capability
- ROM program (easily reprogrammed)
- Digital I/O capability
- Programmable analog output
- Options maximize price/performance
- For systems, production, laboratory, maintenance, and test

The 5376A Systems Programmer is a programming device for the 5360A Computing Counter. The 5360A/5376A combination provides solutions to problems that formerly required the use of a computerized instrumentation system.

This versatile combination finds wide use in several general application areas. . . .

(i) data reduction, e.g. crystal inductance
transducer linearization
equation solving
phase, accumulative phase, etc.

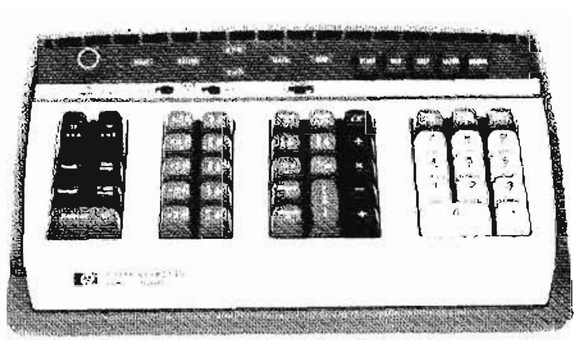
(ii) statistical analysis, e.g. mean
standard deviation
fractional frequency deviation
peak-peak fm deviation
peak-peak time jitter
maximum access time

(iii) process control — provides stimulus
measures response
generates appropriate control signals

Price: prices start at $1350. There are eight options available. See data sheet for details.

Computation

5375A Keyboard



5375A

A laboratory tool for simultaneous data reduction or statistical analysis with measurements.

Similar to the Systems Programmer. The Keyboard is a programming device for the Computing Counter. The read-write memory enables programs to be entered or modified quickly and easily via the appropriate keystrokes. This makes it ideally suited for the laboratory environment.

Operations

Arithmetic: add, subtract, multiply, divide, square root, 10X and 1/10. In addition, short algorithms are available to program for logarithm and exponential.

Measurement: MODULE A, MODULE B, PLUG-IN. Single keystrokes of any of these keys allow measurements to be made from the A input of the 5365A Input Module, the B input or the plug-in respectively.

Price: $1450.

Applications literature

The Computing Counter System is a powerful tool that provides solutions to problems in many applications areas. In a continuing program, a substantial amount of applications literature is available, free of charge, on request.

Application sheets

Single page descriptions of specific problems and their solution with the Computing Counter System. This program covers a wide range of applications from hydrophone testing through crystal inductance measurements to Doppler range rate errors.

Application notes

More detailed treatment of general applications areas. Four are now available:

AN 116 Precision Frequency Measurements
AN 120 A New Technique for Pulsed RF Measurement
AN 120-2 Measuring Phase with the 5360A
AN 120-3 Non-Linear System Applications of the Computing Counter System

Programming manuals

Comprehensive manuals are available on programming the Computing Counter System from the 5375A Keyboard and the 5376A Systems Programmer. Titles are "Programming the 5375A Computing Counter Keyboard" and "5376A Systems Programmer User's Manual." This latter includes a comprehensive treatment of integrating the 5360A-5376A into an operational system.

Hewlett-Packard Journals

Four issues of this widely read publication deal with the Computing Counter System.

May 1969: 5360A/5365A Computing Counter and the 5379A Time Interval Plug-in.
March 1970: 5375A Keyboard.
December 1970: 5376A Systems Programmer.
November 1971: Frequency Stability Measurements.

Accessories

10536A Adapter: adapts following 5245 series plug-ins to the computing. Counter: 5253B, 5254C, 5255A, 5256A, 5258A, 5252A, 5261A. 5257A also compatible except gate time extender does not work.

Price: $225.

5050B Opt. 061 Digital Recorder: This reliable 18 column recorder provides a printed record of 5360A measurements at rates up to 20 lines per second.

Price: $3465.

K01-5360A Serial-Parallel Converter: converts serial bcd output from 5360A into a parallel form compatible with the conventional HP 5050B and 5055A Digital Recorders.

Price: $995.

NORMALIZING COUNTERS

Most versatile preset counters available

Models, 5330A, 5330B, 5332B

5330B, Option 001

Hewlett-Packard Model 5330A features a preset (variable) time base for normalized measurements and Model 5330B combines this variable time capability with dual preset limits. Additionally, a presettable count offset is offered in either model as an option. These instruments were designed for physical measurements in laboratories, automatic control systems, and for digital measurement of all types in engineering and industry.

Models 5330A and 5330B measure in directly usable engineering units such as GPM, PSI, RPM in real time from rate or frequency type input signals. Preset digit switches are used to vary the length of counting time or to multiply or divide the number of input cycles, depending on which one of four operating modes are employed: rate (frequency); time (period); ratio; or F/MN (frequency division). While counting is in progress, a gate signal is issued from a rear panel jack and may be used as a control or timing signal.

The 5330B includes two separate 5-digit limit switches (L1 and L2) for limit control and testing applications. Three high-speed output signals associated with the L1 and L2 limits indicate when the measured value is below (LO), between (IN), or above (HI), these limits. The signals can be used to drive controllers or relays for speed control, for shutdown at predetermined totals, to actuate alarms at pre-shutdown totals, for precise timing of processes, etc.

Offset counting is possible via Option 001 which provides another 5-digit switch, designated "R". This switch may be set to any number from 0 to 99,999, which presets the counter such that counting of the input signal will start from this selected number and reset to this number each cycle. Both instruments are available with digital output and complete programmability. Further information and specifications are available in a detailed data sheet.

Price: 5330A, $1275; 5330B, $1695; Option 001, $100.

Preset controller/counter

Model 5332B

5332B

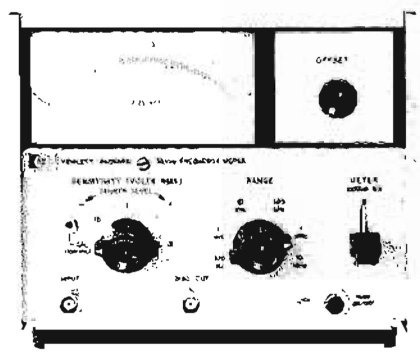
This preset controller/counter counts electrical events and issues output signals when preset count values are reached and measures and limit-detects input rates or frequencies. This instrument provides all the features required in digital control and measurement applications: local and remote control, three versatile operating modes, wide frequency and voltage counting range, very fast recycling, high input impedance and sensitivity, lighted overflow indicator, and BCD output for recording or further digital processing. Applications include batching and precise control of weight, liquid level, length, rate, frequency, etc. The counter can also generate precise time intervals (or delays) and pulse trains, and can measure time intervals precisely. Use of integrated circuits provides compactness and maximum versatility coupled with economy, low power consumption, and low heat dissipation.

The 5332B has a crystal time base to permit limit-detecting frequencies (or rates) of random or periodic events from 0 to over 2 million pps at precise gate times of 0.01, 0.1, 1.0, and 10 seconds. Similarly frequencies up to 10 MHz can be measured. These instruments also measure and limit-detect single and multiple frequency ratios as well as time intervals from 10 μs to 1.0 second.

Remote control and parallel BCD output are standard. For further details and specifications a technical data sheet is available.

Price: 5332B, $1325.

FREQUENCY METER
Wideband, highly linear FM discriminator
Model 5210A



5210A

The Model 5210A Frequency Meter/FM Discriminator directly measures frequency or repetition rate of signals from 5 Hz to 10 MHz, independent of input voltage waveform. A sensitivity control allows for measurement of noisy signals. The special log linear scale offers an accuracy of 1% of reading from 10% of full scale up. With calibrated offset (Option 001) the accuracy is up to 0.2% of full scale.

The 5210A is also a wideband highly linear FM discriminator with a 3 dB output bandwidth of better than 1 MHz for precise measurements on FM and PM signals. With output filters (HP 10531A) frequency deviation, modulation index, frequency response, distortion, incidental FM, and FM noise can be determined as well as "flutter" and "wow" to better than 100 dB below carrier frequency.

For more application details see the data sheet, Hewlett-Packard Journal, March, 1967, and Hewlett-Packard Application Note 87.

HP 10531A, Filter Kit

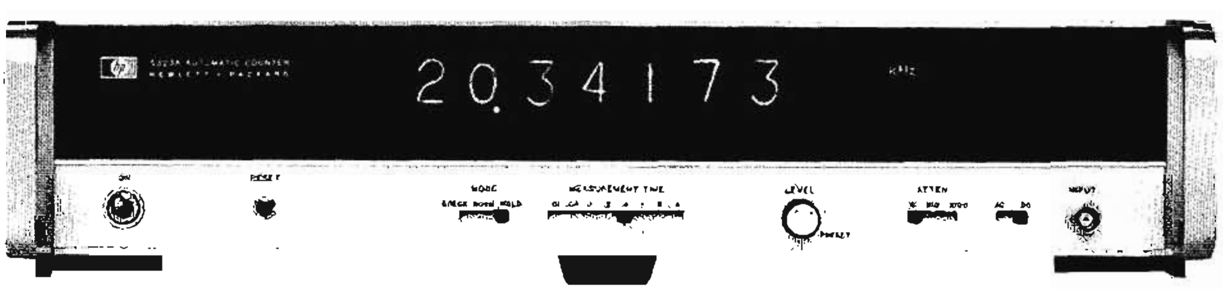
The HP 10531A Accessory Filter Kit provides a series of three plug-in low pass filters which can be adjusted to cover frequencies from 100 Hz to 1 MHz. These filters reject carrier and carrier harmonics while passing modulation components. Thus it is possible to measure demodulated signal components up to 20% of the carrier frequency using the Hewlett-Packard wave analyzers or similar narrow band voltmeters.

Option 001, calibrated offset

The calibrated offset provides for display of any of the 10 major divisions on a separate full meter scale (the EXPAND scale). This allows frequency measurements to be made with higher accuracy than is possible using the meter in the NORMAL mode.

Price: HP 5210A, $850; Option 001, add $125; HP 10531A, $250.

5323A Automatic Counter



Model 5323A

This direct reading electronic counter departs from traditional counter design to offer: much greater resolution and speed when measuring low frequencies (10^3 times greater resolution at 100 Hz); automatic operation; measurement over the entire frequency range using any gate time up to 4 s, including non-decade and unknown values; and direct measurement of pulsed signal carrier frequency. Since the counter automatically displays high resolution measurements from 0.125 Hz to 20 MHz without requiring gate time selection, ease of use and speed are increased both in visual readout and automatic systems applications. For tachometry applications, a rear panel X60 multiplier converts data from pulses per second to revolutions per minute to give a high resolution industrial measurement. Remote programming and digital output are also included.

The 5323A achieves its benefits of speed, resolution, and automaticity by measuring input signal period, then taking the reciprocal, which is frequency, using built-in computing circuits.

A wide selection of measurement times are provided: short times for high speed applications and long times for greater accuracy. Since the 5323A is not limited to either counting or gating in decade values only, additional speed may be achieved by using only the minimum measuring time necessary to obtain the accuracy required.

A full complement of the other features normally found in Hewlett-Packard's latest electronic counters is also provided. Detailed information in the technical data sheet is available upon request, or see Hewlett-Packard Journal, May 1969.

Price: HP 5323A, $1650.

SELECTION GUIDE TO FREQUENCY AND TIME STANDARDS

Hewlett-Packard offers Frequency Standards & clocks which provide accurate frequency, time interval and timekeeping capabilities. Further, Hewlett-Packard standards provide means for comparing these quantities against national standards such as the National Bureau of Standards (NBS) and the U.S. Naval Observatory. Units of frequency or time cannot be kept in a vault for ready reference. They must be generated for each use, hence be regularly compared against recognized primary standards.

Frequency Standard & clock systems manufactured by Hewlett-Packard are used for control and calibration at observatories, national centers for measurement standards, physical research laboratories, missile and satellite tracking stations, radio navigation systems, manufacturing plants and radio monitoring and transmitting stations.

Types of frequency standards

At the present time, three types of frequency standards are in common use. These are:

1. The cesium atomic beam controlled oscillator.
2. The rubidium gas cell controlled oscillator, and
3. The quartz crystal oscillator.

Hewlett-Packard is the only manufacturer of all three types of frequency standards. Of these three standards, the first is a primary frequency standard and the last two are secondary frequency standards. The distinction between a primary standard and a secondary standard is that the primary standard does not require any other reference for calibration; whereas the secondary standard requires calibrations both during manufacturing and at certain intervals during use depending on the accuracy desired.

Cesium beam frequency standard

Cesium beam standards are in use wherever the goal is a very high accuracy primary frequency standard. In fact, the NBS frequency standard itself is of the cesium beam type. The cesium beam standard is an atomic resonance device which provides access to one of nature's invariant frequencies in accord with the principles of quantum mechanics. The cesium standard is a true primary standard and requires no other reference for calibration.

The HP Model 5061A is a portable cesium beam standard proved capable of realizing the cesium transition frequency to the same levels of accuracy and long-term stability usually achieved by large-scale laboratory models. Recent beam tube improvements have made the short term stability comparable to that of the Rubidium Frequency Standard. With this improved performance cesium standards now have the capability of rapid measurement to high precision along with the excellent long term stability necessary for time keeping.

TABLE 1

Comparison of Frequency Standards

Standard	Principal construction feature	Principal advantage
Cesium Atomic Beam Resonator ControlledOscillator	Atomic beam interaction with fields-minimum disturbances of resonating atoms due to collisions and extraneous influences	High intrinsic reproducibility and long-term stability Designated as primary standard for definition of time interval.
Rubidium Gas Cell Resonator Controlled Oscillator	Gas buffered resonance cell with optically pumped state selection	Compact and light weight. High degree of short-term stability
Quartz Crystal Oscillator	Piezoelectrically active quartz crystal with electronic stabilization	Very compact, light and rugged. Inexpensive

Rubidium frequency standard

Rubidium frequency standards feature a high order of both short-term and long-term frequency stability. These are both important in certain fields such as deep-space communications, satellite ranging, and doppler radar. Also, rubidium standards are noted for being of small size.

Rubidium standards are similar to cesium beam standards in that an atomic resonant element prevents drift of a standard frequency quartz oscillator through a frequency lock loop. Yet the rubidium type is a secondary standard. Since the atomic resonant frequency of a rubidium gas cell is dependent upon gas mixture and gas pressure in the cell, it must be calibrated and then it is subject to a small degree of drift. The drift is typically 100 times less than the best quartz crystal standard.

Quartz crystal oscillators

Quartz oscillators are used in virtually every frequency control application. They are an integral part of atomic standards and are used extensively as independent frequency sources for the less demanding applications. The quartz oscillator designs have improved over the years to provide a relatively low cost, small size source of frequency.

However, an inherent characteristic of crystal oscillators is that their resonant frequency changes with time. After an initial aging period of a few days to a month, the rate of change of frequency or aging rate is almost constant. Over a long period the accumulated drift could amount to a serious error, and periodic frequency checks are needed to maintain an accurate quartz crystal frequency standard.

Stability

Stability is specified in two ways, long-term and short-term. Long-term stability refers to slow changes in the average frequency with time due to secular changes in the resonator and is usually expressed as a ratio, $\Delta f/f$ for a given period of time. For quartz oscillators this is often termed "aging rate" and specified in "parts per day." Rubidium standards being more invariant are specified in "parts per month." On the other hand, Cesium Beam Standards are primary units having little or no change or drift. Therefore, these primary standards are given a specified accuracy to within which the frequency is guaranteed.

Short-term stability refers to changes in frequency over a time sufficiently short so that change in frequency due to long term effects is negligible.

Short-term stability is usually specified as the rms average of a number of measurements each over a specified period of time and this averaging time should be given. The longer the averaging time used, the more any deviation is obscured since the average must approach the mean or nominal output frequency in the long run. Hewlett-Packard specifies the short-term stability of its standards in accordance with the definition developed by the National Bureau of Standards and others.* Measurements conforming to this definition can be easily made with available test equipment including the HP 5360A Computing Counter. Figure 1 is a comparison of the short term stability of various frequency standards.

* Statistics of Atomic standards D. Allen, Proceedings of IEEE, Feb. 1966, p. 221.

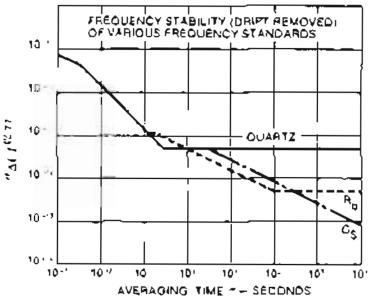


Figure 1. Short term stability of various standards.

Spectral purity

Spectral purity is the degree to which a signal is coherent or, expressed in another way, a single frequency with a minimum of side band noise power. It is greatly desirable to have high spectral purity in a standard signal. This is especially important in applications where the standard frequency is multiplied to very high or microwave frequencies so that the frequency spectrum of the signal will be reasonably narrow.

The signal and its frequency spectrum are analogous to a frequency modulated wave where the total power is constant. If the frequency multiplying device is broadband, the ratio of the total sideband power to the signal power increases as the square of the multiplying factor. With frequency multiplication the signal-to-noise ratio will be degraded 6 dB per octave and 20 dB per decade.

Hewlett-Packard oscillators are designed to give exceptional spectral purity. One method of indicating spectral purity is with a phase noise plot. Figure 2 shows the performance of the HP 5061A, Opt. 04 Cesium Beam Atomic Frequency Standard. (See Hewlett-Packard Application Note 52, "Frequency and Time Standards," pages 3-4 and 5-1 for details of noise measurement).

Frequency standards and clocks

Frequency standards and clocks have no fundamental differences—they are based upon dual aspects of the same phenomenon. Time and frequency are intangible quantities which can be measured only with respect to some physical quantity. The basic unit of time, the second, is defined as the duration of 9,192,631,770 periods of transition within the cesium atom. Conversely an unknown frequency is determined by counting the number of cycles over the period of a second.

The U.S. Naval Observatory (USNO) determines and keeps standard time for the United States. The Master Clock at the Observatory, one of the world's most accurate clocks, is made up of an ensemble of more than a dozen Hewlett-Packard cesium beam frequency standards. The USNO directly controls the distribution of precise time and time interval (frequency) from Naval radio stations, LORAN-C (operated by U.S. Coast Guard), Omega and Satellite Navigation Systems. Hewlett-Packard portable cesium standards, "flying clocks," are used to periodically check the synchronization between these stations and the Master Clock.

Hewlett-Packard cesium beam standards are widely used to drive precision clocks because of the extremely good long-term stability and reliability of this primary standard. If a quartz oscillator or other secondary standard is used, it must be evaluated for rate of drift and be kept carefully corrected.

Frequency comparison by VLF broadcast

One excellent way to keep a local system's frequency—hence, time interval—referenced against master time interval is by use of a LF or VLF standard broadcast such as those of the National Bureau of Standards and the Naval Observatory. A prime means for doing this with ease and convenience is the HP 117A Receiver which is designed to monitor the NBS 60 kHz broadcast from WWVB. This unit is a complete system in itself. The strip chart produced by the 117A records minute by minute the results of a precision phase comparison (resolution, 1 μs) of the local signal against the received signal to show frequency offset or error of the local standard.

Time scale

The time interval of the atomic time scale is the International Second, defined in October 1967 by the Thirteenth General Conference of Weight and Measures. Since January 1972 the frequency offset between UTC and Atomic Time has been zero and the UTC time scale is kept in synchronism with the rotation of the earth to within ±0.7 second by step-time adjustments of exactly 1 second, when needed. The UTC signal is broadcast from the NBS station, WWVB (60 KHz) and several other stations throughout the world. The HP 117A VLF receiver will provide direct comparison to this international time (frequency) reference.

Standby power supplies

Minimum down-time, important for any system, is vital to a time standard. Its worth depends directly on continuity of operation. Noninterrupted operation is also important to ultraprecise quartz oscillators.

Hewlett-Packard standby power supplies ensure continued operation despite line interruptions, and operate over a range of ac line voltage to supply regulated dc to operate frequency standards and frequency dividers and clocks. The batteries in the supplies assume the full load immediately when ac power fails.

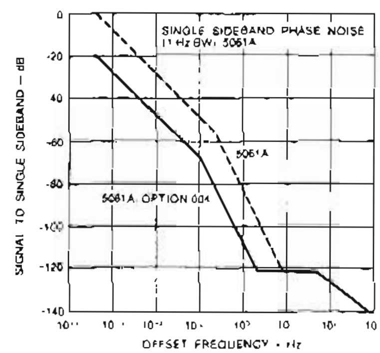


Figure 2. 5061A Opt. 004 Phase Noise.

Hewlett-Packard time and frequency standard

The Hewlett-Packard House Standard consists of an ensemble of three Hewlett-Packard cesium standards including one HP 5061A with an Option 004 high performance tube. The output is continually compared in phase with the U.S. National Bureau of Standards Frequency Standard (NBSFS) at Boulder, Colorado by reception of NBS standards station WWVB via an HP 117A Receiver. The standard may also be compared to the U.S. Navy's VLF stations.

Time is maintained relative to the Naval Observatory and the National Bureau of Standards master clocks to an accuracy of better than ±2.5 microseconds. This accuracy is verified with Flying Clock trips from the Naval Observatory to both Hewlett-Packard Santa Clara Division and Hewlett-Packard Geneva. Both locations have been designated U.S. Naval Observatory Time Reference Stations. Frequency is maintained in agreement with NBS/USNO coordinated time scale with an accuracy of parts in 10^{13}.

DISTRIBUTION AMPLIFIER

Multiple high quality frequency std. outputs

Model 5087A

5087A

Features:

Versatile with 3 input and 12 output channels.

Low noise, high stability and isolation.

The Hewlett-Packard Model 5087A Distribution Amplifier provides the isolation and flexibility required for distribution of the output of high quality frequency standards. Low distortion and excellent isolation make it ideal for providing multiple outputs from atomic or crystal frequency standards. The 3 input channels will accept 10 MHz, 5 MHz, 1 MHz or 100 kHz in any combination with the number of outputs for each channel selectable up to a total of 12 outputs. The output levels are individually adjustable from 0 to 3 V RMS. All input and output levels are monitored on a front panel meter.

The Distribution Amplifier features plug-in modular construction, short circuit isolation, exceptional phase stability, low noise and crosstalk, and uninterrupted switchover to standby DC in event of AC power failure.

The shielding around each input and output plug-in amplifier assures minimum noise and crosstalk. The tuned output amplifiers provide clean signals and high channel-to-channel isolation.

The instrument is designed for maximum versatility and can be supplied to meet a wide variety of special requirements. The standard configuration of input and output amplifiers is shown in Figure 1.

Several other commonly used configurations are also available and special combinations of the various input and output modules can be supplied. Input and output amplifiers can be added or the configuration easily changed at any time.

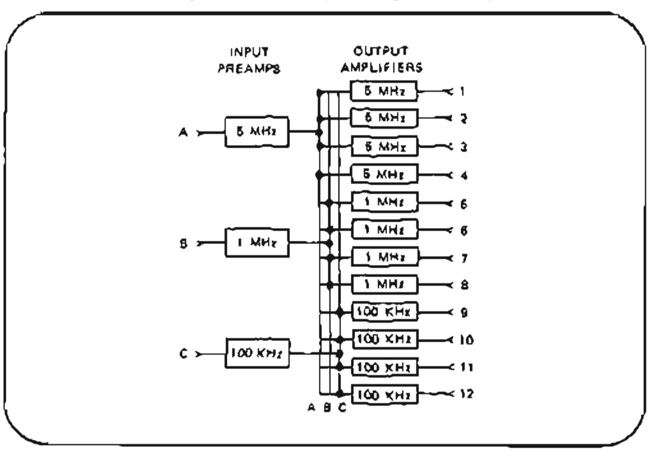


Figure 1. 5087A Distribution Amplifier with Option 031, Standard Configuration of input and output amplifiers. Option 004 broadband input preamplifiers drive four each Option 001, 002 and 003 output amplifiers.

Specifications

Inputs (up to three, rear panel BNC):
- **Frequencies:** 10 MHz, 5 MHz, 1 MHz or 100 kHz.
- **Level:** 0.3 to 3.0 volts RMS, 50 ohms.

Outputs (Up to 12 rear panel BNC):
- **Frequencies:** 10 MHz, 5 MHz, 1 MHz, or 100 kHz.
- **Level:** 0-3 V into 50 ohms (screwdriver adjustment).
- **Harmonic distortion:** >40 dB below rated output.
- **Non-harmonic distortion:** >80 dB below rated output.

Isolation
- **Load** (Open or short on any other channel)
  - **Amplitude change:** <0.1 percent
  - **Phase change:** <0.1 ns at 5 or 10 MHz; <0.5 ns at 1 MHz; <5.0 ns at 100 kHz
- **SSB phase noise (5 MHz):** >145 dB below signal in 1 Hz BW for frequencies >1 kHz from carrier.

Environmental
- **Temperature:** (MIL-E-16400, Class 4)
  - **Operating:** 0-50°C; storage: −62 to +75°C.
- **Stability:**
  - **Amplitude:** ±0.5 dB, 0 to 50°C.
  - **Phase:** <0.1 ns/°C, 5 and 10 MHz.
- **EMC:** MIL-STD-461A. **Vibration:** MIL-STD-167.
- **Humidity:** 95% at 40°C. **Altitude:** Up to 30,000 ft.
- **Shock:** MIL-T-21200, Class 1 and MIL-E-5400 (30 G's).

Power: 115 or 230 V ±10%, 48 to 440 Hz, 20 VA, max, or 22-30 V DC, 500 milliamperes, max.

Dimensions: 3-15/32" x 16¾" x 11¼" (88 x 425 x 286 mm).

Weight: Typical, Option 031—Net 15 lb (7 kg).

Price:

5087A: Distribution Amplifier Mainframe	$725
Normal configurations (input and output amplifiers):	
Option 031: 5, 1 and 0.1 MHz inputs and 4 outputs at each frequency	$835
Option 032: Single 5 MHz input and 12 outputs	$775
Option 033: Single 10 MHz input and 12 outputs	$775
Option 034: Single 5 MHz input, 4 each outputs at 5, 1 and 0.1 MHz	$905
Special configurations:	
Input preamplifiers (up to 3 total):	
Option 004: Input Preamplifier (0.1 to 10 MHz)	$ 30
Option 005: 5 to 1 MHz Input Divider	$ 65
Option 006: 1 to 0.1 MHz Input Divider	$ 65
Option 011: 5 to 10 MHz Input Doubler	$ 65
Option 013: 10 to 5 MHz Input Divider	$ 65
Option 014: 10 to 1 MHz Input Divider	$ 65
Output amplifiers (up to 12 total):	
Option 001: 5 MHz Output Amplifier	$ 65
Option 002: 1 MHz Output Amplifier	$ 65
Option 003: 0.1 MHz Output Amplifier	$ 65
Option 012: 10 MHz Output Amplifier	$ 65

Frequency and time reference systems

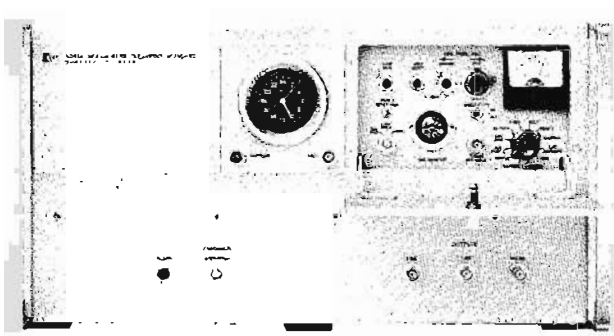
The Hewlett-Packard Cesium and Rubidium Standards can be used as the key elements in a wide variety of frequency and timekeeping systems. The 117A VLF Comparator and special Hewlett-Packard phase comparison instruments may be used for monitoring performance and Hewlett-Packard counters and printers for calibration of other equipment. The 5087A provides a means to distribute standard frequencies throughout a lab or plant. Special built-in fixed frequency synthesizers and a choice of tunable synthesizers with outputs to 1300 MHz can provide signals with atomic standard stability.

Contact your Hewlett-Packard Field Engineer to discuss details of a system tailored to meet your specific requirements.

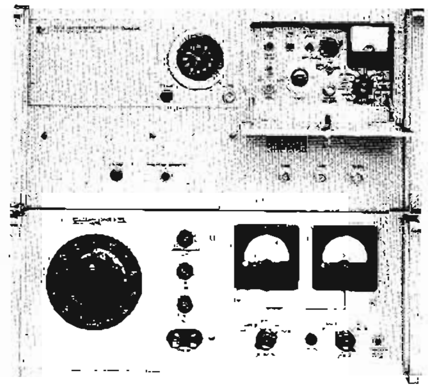
CESIUM FREQUENCY STANDARD

Compact primary standard, 7×10^{-12}

Models 5061A, E21-5061A



5061A



E21-5061A

High Performance Option

Advantages

Accuracy of ± 7 parts in 10^{12}
Settability of 1×10^{-13}
Short term stability of 5×10^{-12} (1 s avg.)

The Hewlett-Packard Model 5061A primary frequency standard with the new option 004 cesium beam tube offers increased stability and accuracy in the instrument which has become the worldwide standard of frequency and time-keeping since its introduction in 1967. Improvements in magnetic shielding, ruggedization and environmental performance will permit improved performance and expansion of navigation and communication systems that have been made practical by the 5061A.

The design concept of the high performance beam tube includes dual beam optics with higher beam intensity to accomplish better short term stability and greater immunity to effects of shock and vibration. A 50 percent increase in resonance cavity length without change in the overall beam tube size contributes to better accuracy and settability because of the narrower resonant line width or higher Q. This tube retains the unique cesium standard feature of virtually no long term instability or aging. This new beam tube is offered as Option 004 in new instruments and is also available in a retrofit kit for units already in use.

The intrinsic accuracy is improved to 7×10^{-12} (5×10^{-12} excluding environmental effects) which provides an excellent reference standard without need of calibration. If desired, such as in many timekeeping applications, two or more units may be set or calibrated to each other. The new settability specification of 1×10^{-13} means two calibrated units (clocks) would accumulate less than 10 nanoseconds per day time error (excluding environmental effects). A provision for degaussing the tube without adversely affecting the instrument operation allows removal of any residual magnetic field in the tube. This is important in achieving the new settability performance. The 10638A Degausser accessory unit is available for use with instruments using the high performance tube.

The short term stability specification is improved by a factor of ten with the new tube. The 5×10^{-12} (1 sec avg.) performance compares very favorably with that of rubidium type standards which are noted for their excellent short term stability. An important advantage from the better short term stability is the capability to make measurements to a 1 sigma precision of 1×10^{-12} in about one minute compared to the two hours required previously.

Within the 5061A Primary Frequency Standard, the beam tube utilizes a quantum mechanical transition in the cesium 133 atom to stabilize a high quality quartz oscillator through a closed-loop, self-checking control circuit yielding exceptional accuracy. The 5061A has provision for an optional digital divider and clock and for a battery with ½ hour standby power capacity with automatic charging.

Accuracy and intrinsic reproducibility

The data in figure 1 is based on over 250 independently aligned standard Model 5061A's. It demonstrates that the cesium beam tube frequency perturbations are so small that all units are within $\pm 5 \times 10^{-12}$ of each other and the National Bureau of Standards. The one sigma standard deviation is 1×10^{-12} between the standards. This performance is intrinsic to the 5061A primary frequency standard and is achieved without calibration.

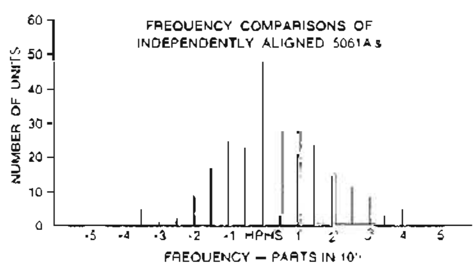


Figure 1.

Reliability and warranty

Over 15 million operational hours have proven the performance and reliability of Hewlett-Packard cesium beam standards in various worldwide applications. The units have provided dependable microsecond accuracy in aircraft, ship, and fixed environments.

A three year warranty on the 5061A and the standard cesium beam tube is provided as a result of proven field reliability over an extended period. The new high performance tube (Option 004) is warranted for 14 months (10,000 hours). This warranty includes replacement of the cesium beam tube if it should fail within the warranty period. Typically, beam tube life has been in excess of 4 years and the high performance tube is expected to prove equally reliable.

Applications

Hewlett-Packard Cesium Beam Standards are used in critical applications such as Apollo timing and missile tracking where their inherent reliability and accuracy play an important role. They are also used in worldwide navigation stations (Loran C and Omega), various national observatories and scientific laboratories around the world, calibration labs, and in the field as very accurate, portable frequency and time standards for instrument and clock calibration. Other areas of application include precision mapping, long baseline interferometry, investigation of radio transmission phenomena, and aircraft collision avoidance systems. As indicated above, success of the cesium beam standard in each of these applications is dependent on its high reliability and accuracy.

E21-5061A flying clock

The E21-5061A consists of a 5061A Cesium Beam Standard with Option 001 clock and a K02-5060A Power Supply (page 287) joined together to make one portable unit. The power supply, which can be operated from 6 or 12 V DC, 24 to 30 V DC, or 115/230 V ±10%, 50 to 400 Hz, will provide approximately 7 hours standby power (from sealed nickel-cadium batteries) for the 5061A Cesium Beam Standard.

This wide range of operating power capabilities enables the E21-5061A to operate on local power in virtually any country in the world. Operation is approved aboard commercial aircraft. The seven hours of standby capability make it possible to travel where there is no power available and, of course, allow the E21-5061A to conveniently be transported between power sources and operated in almost any air or surface vehicle as a "flying Clock" (see Hewlett-Packard Journal, August 1966 and December 1967).

The improved shielding of the Option 004 tube results in a significant increase in accuracy under the varying earth's magnetic field conditions experienced by flying clocks. In addition the better short term stability permits more accurate and rapid comparison of standards.

Weight: 141 lbs (64 kg).

Dimensions: 16¾" wide, 15-15/16" high, 21½" deep (includes handles) (425 x 405 x 546 mm).

Price: E21-5061A (includes Options 001 and 004), $23,780.

Specifications

5061A Cesium Beam Standard, Option 004

Note: Where specifications of the 5061A with the standard tube differ from those with the Option 004 high performance tube, they are enclosed in brackets [ ].

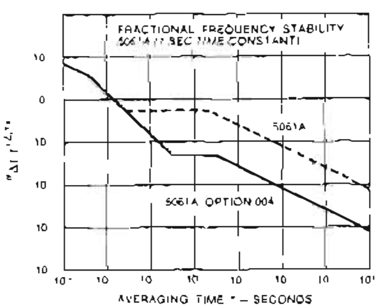
Accuracy: 7×10^{-12}, [1×10^{-11}]; maintained when subjected to temperatures from 0 to 50°C, magnetic fields up to 2 gauss or any combination thereof.

Reproducibility: $\pm 3 \times 10^{-12}$, [$\pm 5 \times 10^{-12}$].

Settability (Frequency): $\pm 1 \times 10^{-13}$ using 10638A degausser, [$\pm 7 \times 10^{-13}$].

Long term stability, (for life of cesium tube): $\pm 3 \times 10^{-12}$ [$\pm 5 \times 10^{-12}$].

Short term stability



Warm-up time: 30 [45] minutes to fully operational from 25°C ambient temperature.

Outputs: 5 MHz, 1 MHz, 100 kHz, >1 V rms into 50 ohms, front and rear BNC.

Haromonic distortion: >40 dB below rated output.

Non-harmonically related output: >80 dB below rated output.

Signal-to-noise ratio: 1 and 5 MHz, >87 dB in 30 kHz noise bandwidth. 5 MHz output filter bw ~ 100 Hz.

Quartz Oscillator: The high quality internal oscillator may be used without turning on the cesium beam tube. See page 284 for specifications.

Warranty: Instrument, 3 years; Optional battery and clock, 1 year; Standard beam tube, 3 years; Option 004 tube, 14 months (10,000 hours).

Environmental

Temperature: operating, 0 to 50°C. Stability, over full operating temperature range, $<\pm 5 \times 10^{-12}$ change from 25°C reference. Nonoperating, −40 to +75°C (+50°C with Options 001 and 002).

Production units have passed type testing as follows:

Humidity: 0 to 95% operating.

Altitude: $<2 \times 10^{-12}$ change up to 40,000 ft operating.

Magnetic: dc field, $\pm 1 \times 10^{-13}$ per gauss, [$<\pm 2 \times 10^{-12}$ any orientation in 2 gauss field].
AC fields, $<\pm 2 \times 10^{-12}$ for 2 gauss peak for 50, 60 or 400 Hz (±10%).

Shock: MIL-T-21200, Class 1 and MIL-E-5400 (30 G's).

Vibration: MIL-T-21200 with isolators and MIL-STD-167.

EMC: MIL-STD-461A and MIL-I-6181D.

General

Power: 115 or 230 V ac ±10%, 50 to 400 Hz, or 22 to 30 V dc. Approx. power: 39 watts dc, 75 watts ac, with Option 003.

Dimensions: 8¾" x 16¾" x 16⅜" (221 x 425 x 416 mm).

Net weight: 67 lbs; Option 001, add 2 lbs; Option 002, add 5 lbs. Option 004, add 3 lbs.

Price: HP Model 5061A only (does not include Option 004), $16,700.

Option 001 Time Standard

Clock pulse

Rate: 1 pulse per second.

Width: 20 μs min.

Rise time: <50 ns.

Fall time: <2 μs.

Amplitude: +10 V ±10% peak.

Jitter: <5 ns rms pulse-to-pulse.

All specs are with 50 ohm load.

Synchronization (rear BNC): automatic, 10 μs (±1 μs) delayed from reference input pulse. Manual adj. to <±50 ns.

Clock movement: 24-hour with sweep second hand.

Price: Option 001, add $1,620.

Option 002 Standby Power Supply

Capacity: (with Option 001): 30 minutes minimum (1 hour typical) at 25°C at full charge.

Price: Option 002, add $645.

Option 003 (combines Option 001 and 002)

Price: Option 003, add $2,265.

Option 004 High Performance Cesium Beam Tube

Includes high performance tube and necessary circuit changes to give improved accuracy, reproducibility and stability performance shown above for Option 004. Options 001, 002 or 003 may be ordered with Option 004. (High performance retrofit kit available to replace the standard beam tube. Consult Hewlett-Packard field sales offices for details.)

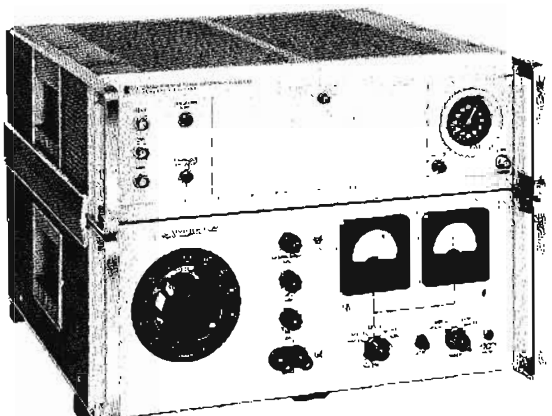
The HP 10638A Degausser is available as an accessory and is required with Option 004 to achieve the settability specifiation.

Price: Option 004, add $2,160.

RUBIDIUM FREQUENCY STANDARD

Compact, lightweight atomic standard

Models 5065A, E21-5065A



E21-5065A

Advantages:

- Low price atomic standard.
- Long term drift rate of $<1 \times 10^{-11}$/mo.
- Short term stability of $<5 \times 10^{-13}$ for 100 s average.
- Calibrated fine frequency adjustment.
- Battery standby power guards against power failure (optional).
- Built in clock and digital divider (optional).
- Rubidium Vapor Frequency Reference warranted 3 years.

Uses:

- Precise frequency source for systems operating in the radio and TV spectrum.
- Precision timekeeping.
- House standards and calibration laboratories.
- Doppler radar.

The HP Model 5065A is an atomic-type secondary frequency standard which uses a rubidium vapor resonance cell as the stabilizing element. As a result, it has long term stability of better than 1×10^{-11} per month which exceeds that of high quality quartz oscillator frequency standards by 50 to 100 times. Furthermore, it has excellent short term stability. These features contribute to its desirability as a coherent signal source, as a master oscillator for radio and radar systems where special requirements for stability and/or narrow bandwidth must be met, as a precision timekeeper where the better performance of a cesium beam primary standard is not required, and as a house frequency standard for improved accuracy with fewer NBS calibrations compared to that required with quartz standards.

Front panel controls and circuit check meter of the 5065A are protected by a panel door. The magnetic field control provides fine frequency adjustment with which the frequency can be set to a precision of better than 2×10^{-12} without reference to a chart. The 5 MHz low noise quartz oscillator is phase locked to the atomic frequency and provides the standard 5 MHz, 1 MHz, and 100 kHz outputs. The circuit check meter with selector switch monitors key voltages and currents for routine maintenance readings, calibration procedures, and fault finding.

The 5065A is designed for assured operation—to give the user confidence that the standard output signals are correct and locked to the atomic frequency. Logic within the unit maintains power to a "continuous operation" light on the front panel. If operation is interrupted, even momentarily, for any reason the light goes out and stays out until manually reset. An integrator limit light warns when the frequency correcting servo loop is approaching the limit of its dynamic range.

A time standard option generates 1 pulse per second available at a front panel BNC connector and drives a clock movement indicating hours, minutes and seconds. The clock pulse is adjustable over a range of 1 second in 1 μs increments to permit precise synchronization with another clock using a counter or oscilloscope. A screwdriver control allows continuous fine adjustment over any 1 μs range. The clock can also be automatically set to a 10 ± 1 μs delay with respect to an external clock pulse.

An optional built in standby battery assures continuous operation of the HP 5065A in the event of brief power failures. The 5085A or K02-5060A Power Supplies will provide battery power for longer periods.

The HP Model 5065A is contained in a small sized package and is lightweight in comparison to a cesium beam standard. Additionally, the rubidium resonance cell is much more frequency stable than quartz oscillators while subjected to shock and vibration. Its environmental specifications include temperature, shock, vibration, EMC, humidity, and magnetic field effects.

The most significant module in the HP 5065A in terms of performance is the Rubidium Vapor Frequency Reference (RVFR). This temperature controlled, magnetically shielded unit which includes the Rb^{87} lamp, Rb^{85} filter cell, microwave cavity with Rb^{87} gas cell and a photo sensitive detector can be expensive to replace. It has been designed for maximum possible reliability. Field experience, including several million hours operation, have demonstrated this reliability and the module is now warranted for a period of three years. This increased warranty protects the owner in the event of a random failure.

E21-5065A

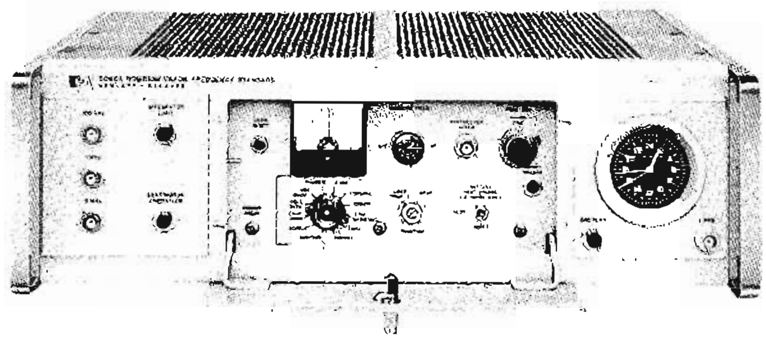
Portable Time Standard

E21-5065A Portable Time Standard is a complete system for precision timekeeping and for transporting time from one location to another. It consists of the 5065A Rubidium Standard with digital clock and divider (option 01) and the K02-5060A Power Supply with 6 or more hours standby capability. The K02-5060A is described in detail elsewhere in this catalog. The component units are held together by side bars, and the interconnecting cables are protected by a back cover.

Weight: 110 lb (50 kg).

Dimensions: 16¾" (425 mm) wide, 12- 3/8 " (314 mm) high, 21½" (546 mm) deep, includes handles .

Price: $12,345.



HP 5065A shown with Option 03 consisting of clock and standby battery

Specifications, 5065A

Frequency stability:

Long term: $\pm 1 \times 10^{-11}$ per month (maximum limit of drift rate).

Short term (5 MHz output):

$\frac{\Delta f}{f}$ (Std. Dev.)	Avg. Time
5×10^{-12}	1 sec.
1.6×10^{-12}	10 sec.
5×10^{-13}	100 sec.

Calibration accuracy: set at factory to $\pm 1 \times 10^{-11}$.

Settability: $\pm 2 \times 10^{-12}$.

Tunability:

Coarse frequency synthesizer adjustment:
Range: 10^{-7}. Resolution: $< 2 \times 10^{-9}$, thumbwheel adjustable.

Fine frequency magnetic field adjustment:
Range: 2×10^{-9}. Resolution: 2×10^{-12}.

Warm-up: within 1×10^{-10} in one hour and 5×10^{-11} in 4 hours after 24 hours "off" time at 25°C.

Outputs:

Frequencies: 5 MHz, 1 MHz, 100 kHz.

Voltage levels: >1 V rms into 50 ohms.

Connectors: BNC front and rear.

Distortion (5 MHz, 1 MHz, 100 kHz) below rated output:

Harmonic: >40 dB.

Nonharmonic: >80 dB.

Signal-to-noise ratio: for 1 and 5 MHz, >87 dB at rated output in a 30 kHz noise bw. 5 MHz output filter bw is approx. 100 Hz.

Environmental:

Temperature, operating: 0° to 50°C. Frequency change is $< \pm 4 \times 10^{-11}$ from frequency reference at 25°C.

Temperature, nonoperating: —40° to +75°. (With Options to 50°C.)

Production units have passed tests as follows:

Humidity: 0 to 95% relative humidity.

Vibration: MIL-STD-167 and MIL-E-5400, Curve 1, with isolators.

Shock: MIL-T-21200, and MIL-E-5400 (30 G's).

Electromagnetic compatibility (EMC): MIL-I-6181D and MIL-STD-461, Class A.

Altitude: frequency change is $< 5 \times 10^{-11}$ from 0 to 40,000 ft.

Frequency stability due to:

Magnetic fields: $< 5 \times 10^{-13}$ for 1 gauss dc change or 1 gauss peak ac, 60 ±10% Hz and 400 ±10% Hz.

Line voltage: $< 4 \times 10^{-12}$ over specified input range.

Power: 115 or 230 V ac ±10%, 50 to 400 Hz; or 23 to 30 V dc. Approx. power required:

	24 V dc	115 V ac
Without options:	35 W	49 W
Option 001 (Add)	7.5 W	10 W
Option 002 (Add)	0 W	6 W
Option 003 (Add)	7.5 W	16 W

Accessories furnished: power cord, 6 ft (180 cm) detachable. Rack Mounting Kit, HP 5060-0775. Accessory Kit, HP 05065-6066, includes Micon connector adapter male-male, mating connector HP 1251-0126 for EXT dc input. 3 circuit board extenders, test cable, and a special coil-tuning screwdriver.

Dimensions: 16¾" (425 mm) wide, 5-7/32" (132.6 mm) high, 16⅜" (416 mm) deep.

Weight: net, 34 lbs (15,4 kg); shipping, 52 lbs (23,5 kg). Option 001 add 2 lbs (,9 kg); Option 002 add 3.5 lbs (1,6 kg).

Accessories available: EXT dc cable: connects 5065A to 5085A Standby Supply, HP 103A-16A, $21.50.

Price: $7,500.

Warranty: 1 year except 3 years for RVFR.

Option 001 time standard

Clock pulse:

Rate: 1 pulse per second.

Amplitude: +10 V peak ±10%.

Width: 20 μs min.

Rise time: <50 ns.

Fall time: <1 μs.

Jitter: <5 ns rms.

All specs are with 50Ω load.

Output: front-panel BNC.

Synchronization: automatic to 10 ±1 μs, delayed from reference input pulse (rear BNC). Manual adj. to ±50 ns. Reference pulse must be >+5 V with a rise time <50 ns and width >0.5 μs.

Clock movement: 24-hour with sweep second hand.

Price: Option 001, add $1,620.

Option 002 standby power supply

Capacity: 10-minute minium at 25°C after full charge (incl. Option 01).

Charge control: front panel, Fast Charge-Float-Reset switch.

Indicator: a front-panel light flashes when ac power is interrupted and battery is being used. A continuous light indicates a fast charge condition.

Price: Option 002, add $320.

Option 003

(Combines Options 001 and 002)

Price: Option 003, add $1,940.

Performance of quartz oscillator only

(Rubidium Control Loop Open)

Aging rate: $\pm 5 \times 10^{-10}$ per 24 hours.

Frequency adjustments:

Fine adjustment: 5×10^{-8} range, with dial readings of parts in 10^{10}.

Coarse adjustment: 1 part in 10^{6}, screwdriver adjustment at front panel.

Stability:

As a function of ambient temperature: frequency change is less than 2.5×10^{-9} total from 0° to +50°C.

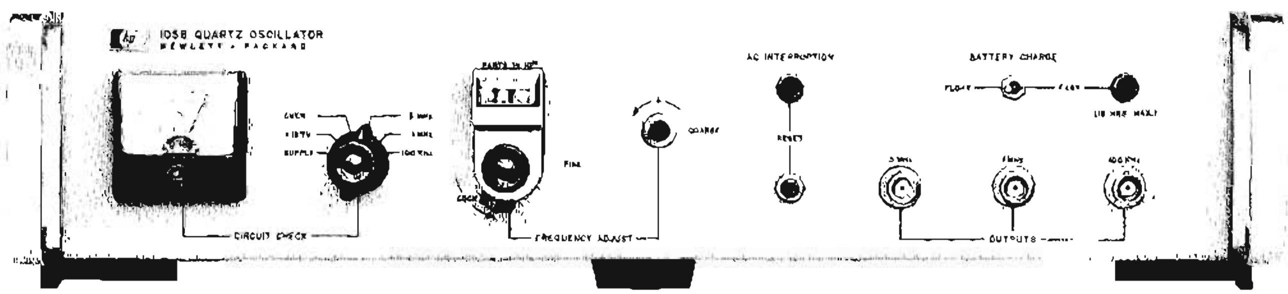
As a function of load: $\pm 2 \times 10^{-11}$ from open circuit to short, 50Ω R, L, or C load change.

As a function of supply voltage: $\pm 5 \times 10^{-11}$ for 23 to 30 V dc from 26 V dc reference, or for 115/230 V ac ±10%.

QUARTZ FREQUENCY STANDARDS

State-of-the-art frequency stability

Models 105A/B



105B

Advantages:

- High spectral purity
- Well-buffered outputs
- Aging $<5 \times 10^{-10}$ per day

Uses:

- In-house frequency and time standards
- Microwave spectroscopy
- Advanced navigation, communication systems

Models 105A and B Quartz Oscillators provide state-of-the-art performance in precision frequency and time systems because of their excellent long and short term stability characteristics, spectrally pure outputs, unexcelled reliability, and ability to operate under a wide range of environmental conditions. They fill a need for a small and economical yet highly stable precision quartz oscillator for frequency and time standards. Both models can be operated from the ac line; the 105B has a built-in 8-hour standby battery for uninterrupted operation should line power fail. Both have 5 MHz, 1 MHz, and 100 kHz buffered sinusoidal outputs with excellent short term stability (5 parts in 10^{12} rms for 1 s averaging time) and aging rate (<5 parts in 10^{10} per day).

The 105A/B features rapid warm-up. Typically, the oscillator will be within 1 part in 10^9 of the previous frequency in 20 minutes after an "off" period of 24 hours. The basis of these oscillators is an extremely stable 5 MHz, 5th overtone quartz crystal developed by Hewlett-Packard. New technologies in the crystal mounting and packaging have resulted in a cleaner crystal which in turn has a lower aging rate. The crystal, oscillator and AGC circuit are all enclosed in a proportional oven which reduces the temperature effects on these components and circuits.

The 2.7" x 2.7" x 5.4" package containing the oven enclosed crystal oscillator with AGC circuit and buffer amplifier are available separately as a component oscillator, the K07-105A, for use in equipment where a high quality 5 MHz source is required. Details are available from Hewlett-Packard sales offices.

Particular care was taken to provide a spectrally pure 5 MHz output which, when multiplied high into the microwave region, provides signals with spectra only a few cycles wide. Spectra less than 1 Hz wide can be obtained in X-band (8.2 to 12.4 GHz). The stability and purity of the 5 MHz output make it suitable for doppler measurements, microwave spectroscopy, and similar applications where the reference frequency must be multiplied by a large factor.

Specifications

Outputs: 5 MHz, 1 MHz, 100 kHz; 1 V rms into 50Ω front and rear connectors.

Clock output: 1 MHz or 100 kHz; 0.5 V rms into 1 KΩ, rear connector. Normally supplied wired for 1 MHz output.

Frequency stability:

Aging rate: $<5 \times 10^{-10}$ per 24 hours.

Short-term stability: for 5 MHz output only.

τ (sec)	$\sigma_{\Delta f/f}(2, \tau)$	$\sigma_{\Delta t}(2, \tau)$ sec
10^{-2}	1.5×10^{-10}	1.5×10^{-12}
10^{-1}	1.5×10^{-11}	1.5×10^{-12}
10^{0}	5×10^{-12}	5×10^{-12}

Temperature: $<2.5 \times 10^{-9}$ total change 0°C to 50°C.

Load: $\pm 2 \times 10^{-11}$ open to short circuit, 50Ω R, L or C load change.

Supply voltage: $\pm 5 \times 10^{-11}$ for 22-30 V dc from 26 V dc reference and for 115/230 V ±10%.

Warm-up (at 25°C): to within 1×10^{-7} of previous frequency in 15 min., 1×10^{-8} in 20 min., 1×10^{-9} in 30 min.

Distortion (5 MHz, 1 MHz, 100 kHz) below rated output:

Harmonic: >40 dB.

Nonharmonic: >80 dB.

Signal-to-noise ratio: for 1 and 5 MHz, >90 dB in a 30 kHz noise bw (5 MHz output filter bw is approximately 100 Hz).

Frequency adjustments:

Fine: 5×10^{-8} range with digital dial reading parts in 10^{10}.

Coarse: 1×10^{-6} front panel screwdriver control.

Phase locking: external +5 V to −5 V allows $>2 \times 10^{-8}$ frequency control for locking to external source.

Environmental:

Temperature, operating: 0°C to +50°C.

Temperature, storage: −40°C to +75°C (+50° for 105B).

Altitude: 50,000 ft

Shock: MIL-T-21200 (30 G's).

Vibration: MIL-STD-167 and MIL-T-21200.

Electromagnetic compatibility (EMC): MIL-I-6181D.

Standby supply capacity: Model 105B only, 8 hours at 25°C ambient temperatures.

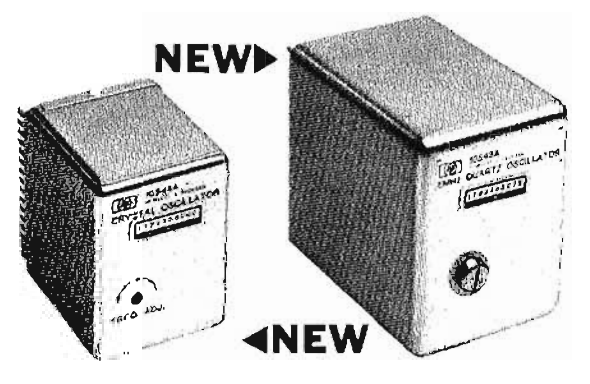
Power requirements: 115/230 V ±10%, 50-400 Hz at 17 W (70 W warm-up) for 105A. For 105B add 1 W for float charge and 12 W for fast charge. 22-30 V dc at 6.4 W (10.3 W warm-up).

Dimensions: 3-15/32" high, 16¾" wide, 11¼" deep (88 x 425 x 286 mm).

Weight: 105A—net, 16 lbs (8 kg); shipping, 23 lbs 10,5 kg). 105B—net, 24 lbs (11 kg), shipping, 31 lbs (14 kg).

Price: Model 105A, $1775; Model 105B, $2145.

COMPONENT OSCILLATORS
Aging $<5x10^{-10}$/day
Models 10543A, 10544A



10544A 10543A

Advantages: excellent spectral purity, rugged, high reliability, compact, low power, fast warm-up.

Uses: test instruments—counters, synthesizers, navigation and communication equipment.

The 10543A and 10544A Quartz Crystal Oscillators were developed by Hewlett-Packard to meet the needs for compact, high stability oscillators for use in test equipment and systems. Their excellent short term stability and high spectral purity are especially desirable in applications where multiplication and synthesis are used to generate microwave frequencies. Rugged construction and high quality components assure high reliability and optimum performance. With the extremely low aging rate of these oscillators a significant cost savings can be realized by the end user because of the reduced frequency of calibration needed to stay within FCC accuracy requirements.

Crystals for both oscillators are supported in a new rugged mounting in a cold-welded, high bake out enclosure. The housing around the crystal enclosure is massive with high thermal conductivity which contributes both to rapid warm-up and excellent temperature stability. The oscillator, AGC amplifier and proportional oven control circuits are all inside a thermally insulated oven. Rigid plastic foam with extremely low thermal conductivity is used to provide thermal insulation and firm mechanical support for the oven enclosure.

These two oscillators differ in the oven control circuits, thermal insulation, input voltage requirement and output impedance. The 10543A uses a thermistor bridge oven control with a control transistor mounted so that power dissipated in the transistor is used to supply part of the oven heat. Added thermal insulation plus a built in voltage regulator and buffer amplifier for 50 ohm output contribute to the larger size of this oscillator.

The 10543A is housed in a sealed enclosure with a gasketed screw to seal the coarse tuning adjustment. An internal voltage regulator supplies the oscillator and temperature control circuits so that a single 16 to 30 volt source will operate the unit. The output buffer amplifier is short circuit protected and delivers one volt into a 50 ohm load. With the excellent stability of the 10543A over the temperature range of $-55°C$ to $+71°C$ the oscillator is well suited to use in portable navigation and communication systems which require a state-of-the-art quality oscillator.

Low priced and more compact the 10544A uses an efficient thermistor control of the heater current duty cycle to maintain the oven temperature. The oven heater may be operated over the range of 15 to 30 V while the oscillator and oven controller require a regulated 10.6 to 11.7 V source. A simple external IC regulator may be used if the necessary voltage is not available. The 10544A is ideally suited for use in electronic counters, synthesizers, precision signal sources, and fixed station communication systems which require low aging, high stability oscillators.

Both oscillators have 18-turn coarse tuning control. The electronic frequency control permits fine frequency adjustment or phase locking of the oscillators.

Specifications

Model	10543A	10544A
Frequency (1)	5 MHz	10 MHz
Output—Voltage, rms	1 V ±10%	1 V ±20%
Impedance, ohms	50	1000
Frequency stability, aging rate (2)	$<5x10^{-10}$/day	$<5x10^{-10}$/day
	$<1.5x10^{-7}$/year	$<1.5x10^{-7}$/year
Short term, Avg. time 10^{-1} s	$2x10^{-9}$	
10^{-2} s	$5x10^{-11}$	
1 s	$1x10^{-11}$	$1x10^{-11}$
10 s	$1x10^{-11}$	$1x10^{-11}$
100 s	$1x10^{-11}$	$2x10^{-11}$
Temperature, 0 to 71°C	$<2x10^{-9}$	$<3x10^{-9}$
−55°C to +71°C	$<5x10^{-9}$	$<1x10^{-8}$
Load	$<2x10^{-10}$, ±5Ω	$<5x10^{-10}$, ±250Ω
Warm-up, (3) 25°C, at 20 V dc	$<2x10^{-9}$ in 30 min.	$<5x10^{-9}$ in 15 min.
Supply voltage, 16-30 Vdc	$<2x10^{-10}$, ±10%	$<1x10^{-10}$, ±10%
10.6 - 11.7 Vdc regulated		$<5x10^{-10}$, ±1%
Distortion below rated output:		
Harmonic	>30 dB	>25 dB
Nonharmonic	>100 dB	>80 dB
SSB phase noise ratio (1 Hz BW)		
Offset from carrier—10 Hz	120 dB	115 dB
100 Hz	135	120
1 kHz	145	125
10 kHz	145	130
Frequency adjustment:		
Coarse (18-turn control)	$>5x10^{-7}$	$>4x10^{-6}$
Fine (EFC)	$>1x10^{-7}$	$>1x10^{-7}$
Connector	9-pin miniature	15 pin PC Board
Input power, 25°C	3.5W @ 20V	2.75 watts
Case size	2.5x3.3x3.7"	2.8x2x2.4"
Weight:	20 oz.	11 oz.
Price: (quantity discounts avail.)	$850	$450

Notes: (1) Special order: 10543A, 10 MHz, 10544A, 5 MHz.

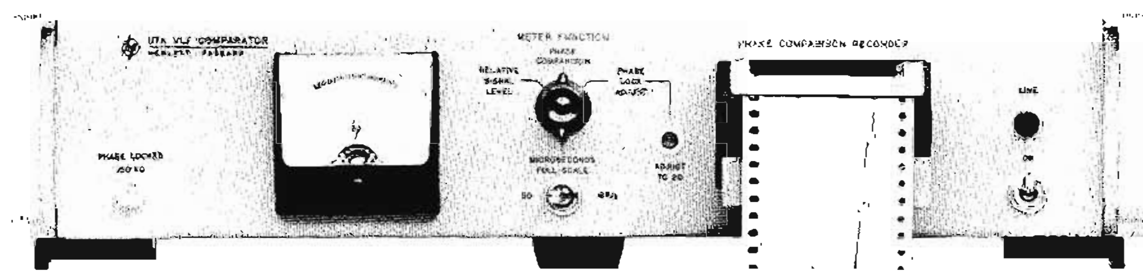
(2) For off-times of less than 24 hours, 5×10^{-10}/day is achieved within 24 hrs after turn-on.

(3) e.g.: Within 30 min. after turn-on, 10543A freq. will be $<2 \times 10^{-10}$ away from "final" value. "Final" value is freq. reached 24 hrs after turn-on.

VLF COMPARATOR

Compares frequency against NBS standard

Model 117A



117A

Advantages:

Parts in 10^{11} accuracy possible over 24-hour period
Provides traceability to national standards
Plots minute-to-minute phase record
Provides all equipment needed for frequency comparison

Uses:

Offset and drift determinations for crystal oscillators
Quick and easy checks of counter time-base accuracy
Monitors atomic standards against national standard

The HP 117A VLF Comparator measures the frequency offset of a local standard frequency source against a standard radio frequency to an accuracy that can reach 2 parts in 10^{11} in a 24-hour period or parts in 10^{12} over longer periods. The 117A receiver thus provides a link between house frequency standards and national standards. The 60 kHz broadcast by WWVB links the Boulder, Colorado laboratories of the National Bureau of Standards (NBS) with the entire continental United States and adjacent areas in Canada and Mexico.

The H88-117A is modified to receive the 60 kHz broadcast from MSF in Rugby, United Kingdom, providing a link to the standards maintained by the National Physical Laboratory. The H44-117A is designed to receive the 75 kHz broadcasts of HBG in Prangins, Switzerland.

The strip chart record of the HP 117A provides a precision phase comparison to show frequency offset of the local standard permitting its calibration to parts in 10^{10} in a few hours or long term monitoring to measure oscillator drift rate. A transparent template overlayed on the recording enables the operator to read at a glance the frequency offset of his local standard. A front panel meter shows relative level of the received signal, proper adjustment of the phase-locked oscillator and phase difference. Full-scale chart width and meter reading can be set for either a 50 μs or 16⅔ μs phase difference.

Rear panel outputs provide for connection to external meters or recorders. An external recorder with a chart speed of several inches a minute can be used to record the amplitude modulated time code giving time of day and UT1 time corrections broadcast by WWVB.

The VLF Comparator is a complete receiver system for comparison of a standard broadcast signal with a local standard. It includes a servo-controlled oscillator which functions as a narrow band tracking filter (and assures a continuous output signal despite noise and interference), a linear phase comparator with chart recorder and a loop antenna with a built-in preamplifier which may be located up to 300 meters from the Comparator. The connecting cable also carries power to the preamplifier.

Specifications

Received standard frequency: 60 kHz, NBS Station WWVB.

Sensitivity: 1 μs rms into 50Ω. Min. field strength, 60 μV/meter.

Local standard input: 100 kHz, 1 V rms into 1 KΩ (divider to accept 1 MHz available as option).

100 kHz Phase-locked output: 5 V rectangular positive pulses into 5 KΩ phase-locked to received signal.

Recorder outputs: Phase comparison, 0-1 mA dc into 1400Ω. Relative signal strength, 0-100 mV dc from 2 KΩ.

Overall phase stability: ±1 μs, 0-50°C.

Chart speed: 1 in/hr (6 or 12 in/hr available at extra cost).

Temperature: Operating 0 to 50°C, Storage −50 to 75°C.

Dimensions: 3-15/32" x 16¾" x 11¼" (425 x 88 x 286 mm).

Weight: 117A: 20 lbs (9,1 kg); Antenna: 12.5 lbs (5.7 kg).

Power: 115 or 230 V ±10%, 60 Hz, 40 watts.

Accessories (included):

10509A Loop Antenna: Electrical height 1.6 cm, 43 in. (109 cm) in dia., mounts on 1-in. pipethread. Operating temperature: −60°C to +80°C. (Available separately for use only with HP 117A, $455 incl. 10512A cable).

10512A Coaxial Lead-in Cable: 50Ω BNC connectors, 100 feet (30,5 m) long. Available separately at $40 or in lengths to 300 m on special order.

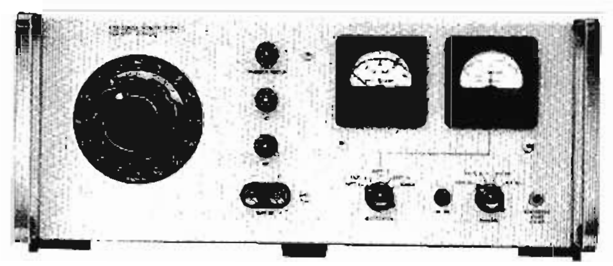
Recorder Chart Paper: One roll shipped with 117A. Box of six 30-ft. rolls, HP # 9281-0081, $8.40.

Prices: (Including 10509A Antenna/Pre-amp and 10512A Lead-in Cable): Model 117A, $1775.

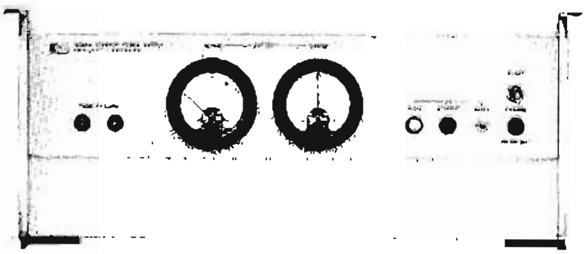
Option H44-117A: 117A modified to receive HBG, 75 kHz, 115/230 V, 50 Hz, $2275.

Option H88-117A: 117A modified to receive MSF, 60 kHz, 115/230 V, 50 Hz, $2215.

STANDBY POWER SUPPLIES
For frequency and time standards
Models 5085A, K02-5060A



K02-5060A



5085A

The HP Models 5085A and K02-5060A Standby Power Supplies furnish dc power to keep frequency or time standard systems operating during extended interruptions of ac line power. For applications where it is essential to maintain continuous operation and avoid loss of precise time, the use of a standby power supply is an absolute necessity. These units are designed for use with the Hewlett-Packard Cesium Beam Standards, Rubidium Vapor Standards, Quartz Oscillators and other equipment which will operate from 26 V dc. No switching is used in transferring power from line to battery operation and back again thus assuring uninterrupted operation.

HP K02-5060A

The K02-5060A is a very versatile unit which was designed specifically as a portable power supply for the 5061A and 5065A "Flying Clocks" where it is necesary to operate from a wide range of power sources along with the standby capability to maintain continuous operation where no external power is available. A special inverter permits operation from a 6 or 12 V dc car battery in addition to the 115/230 V ac and 24-30 V dc capability. The 12 ampere-hour standby batteries are the sealed, nickel-cadmium type and thus spill-proof. Mounting hardware is available to attach the K02-5060A to either the 5061A or 5065A Standards to make a portable standard, the E21-5061A or E21-5065A.

HP 5085A

The HP 5085A is intended for installations where 115 or 230 V ac is available. Vented nickel-cadmium batteries with an 18 ampere-hour guaranteed capacity (derated from 25) are used. They provide about 10 hours of standby power for the 5061A Cesium Standard or 5065A Rubidium Standard (at average ambient temperature of 25°C).

Front panel lights indicate mode of operation, report fuse failure, and ac interrupt. A float-charge switch permits rapid recharge after an ac power failure.

Specifications, K02-5060A

Input and output voltages:

Input	Output
6 or 12 V dc	0-230 V, 60 Hz nominal
115 or 230 V ac, 50-400 Hz	0-230 V ac
24-30 V dc	24-30 V dc

Standby battery, 26 ±4 V dc available at all times.
AC and both dc inputs may be connected simultaneously.

Output current: 0.5 A ac, 2 A dc.
Standby capacity: 12 ampere-hours at 25°C, 7 hours standby when used in E21-5061A, 6 hours in E21-5065A.
Recharging: 1.6 hours recharging time required for each ampere hour of discharge.
Alarm indicator: external power failure.
Panel meters: voltmeter, ammeter indicating voltage and current of 4 internal batteries and load.
Battery: four paralleled rechargeable battery packs each containing 20 sealed nickel-cadmium cells. Packs may be removed individually without interfering with power supply operation.
Temperature: operating, 0 to 50°C.
storage, −40 to 60°C.
Dimensions: 16¾" wide, 6-31/32" high, 16⅜" deep (425 x 177 x 416 mm).
Weight: net, 67 lbs.
Accessories furnished: ac and dc input and output cables.
Price: $2850.

Specifications, 5085A

Output voltage: 24 ±2 V dc at rated current.
Output current: 2 amperes (2.5 A for 30 min.).
Standby capacity: (at 25°C) 18 amp-hrs. after 48 hours charge.
Alarm indicators: panel lamps indicate: (1) FUSE FAILURE, (2) AC POWER, (3) AC INTERRUPT, (4) CHARGE.
Remote alarm provisions: SPDT relay contacts provided at rear terminals for operating remote alarm from separate power system.
Panel meters: battery voltage and charge/discharge current.
Power requirements: 115 or 230 ±10% V ac; 50 to 400 Hz (2.0 A max. at 115 V line).
Battery (supplied): vented nickel-cadmium 25 ampere-hour capacity derated to 18 ampere-hours. Periodic maintenance required.
Additional (external) battery provision: rear connector.
Temperature: operating, 0 to 50°C.
storage, −40 to 75°C.
Dimensions: 16¾" wide, 6-31/32" high, 16⅜" deep (425 x 177 x 416 mm).
Weight: net, 75 lbs (34,1 kg); shipping, 101 lbs (45,9 kg) including battery. Option 001 (no batteries) is 50 lbs (22,8 kg) less.
Accessories furnished:
AC Power Line Power Cable, 6 ft long, DC Output Connector. Instrument Extension Slides (for std. 24" deep rack).
Price: Model 5085A (complete with batteries), $1835.
Options: Model 5085A Option 001, without batteries, $1195.

PULSE and SQUARE WAVE GENERATORS

Pulse and square wave generators are most often used with an oscilloscope as the measuring device. Waveform shapes as seen by the oscilloscope, either at the output or at pertinent points within a system under test provide both qualitative and quantitative evaluations of system or device performance.

Square waves or pulses

The fundamental difference between pulse and square wave generators concerns the signal duty cycle. Square wave generators have equal "on" and "off" periods, this equality being retained as the repetition rate is varied. The duration of a pulse generator "on" period, on the other hand, is independent of pulse repetition rate. The duty cycle of a pulse generator can be made quite low so that these instruments are generally able to supply more power during the "on" period than square wave generators. The HP Model 214A, for instance, supplies up to 200 watts in its output pulse.

Short pulses reduce power dissipation in the component or system under test. For example, measurements of transistor gain are made with pulses short enough to prevent junction heating and the consequent effect of heat on transistor gain.

Square wave generators are used where the low-frequency characteristics of a system are important, such as in the testing of audio systems. Square waves also are preferable to short pulses if the transient response of a system requires some time to settle down.

Pulse generators

In the selection of a pulse generator, the quality of the output pulse is of primary importance. High-quality test pulses insure that degradation of the displayed pulse may be attributed to the test circuit alone.

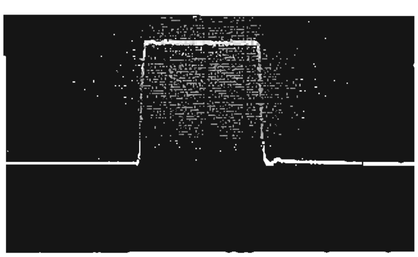


Figure 1. Carefully controlled pulse shapes insure accurate measurements.

The pertinent characteristics of a test pulse, shown in Figure 2, are controlled and specified accurately in Hewlett-Packard pulse generators. Rise and fall times should be significantly faster than the circuits or systems to be tested. Variable rise time and fall time, available in HP 1900 pulse system, HP Models 8002A, 8007A, 8012A, and 8005A, are useful for testing over a wide range of operating conditions.

Any overshoot, ringing, and sag in the test pulse should be known, so as not to be confused with similar phenomena caused by the test circuit.

The range of pulse width control should be broad enough to fully explore the range of operation of a circuit. Narrow pulse widths are useful in determining the minimum trigger energy required by some circuits.

Maximum pulse amplitude is of prime concern if appreciable input power is required by the tested circuit, such as a magnetic core memory. At the same time, the attenuation range should be broad enough to prevent overdriving the test circuits, as well as to simulate actual circuit operating conditions.

The range of pulse repetition rates is of concern if the tested circuits can operate only within a certain range of pulse rates, or if a variation in the rate is needed.

Triggering

The trigger requirements for synchronizing a pulse generator should be evaluated in light of the triggers available in anticipated measurement set-ups. Most Hewlett-Packard pulse generators have versatile trigger circuits similar to oscilloscopes. These circuits synchronize on most waveforms of more than 1 V amplitude.

Hewlett-Packard pulse generators also supply fast rise output triggers for operation of external equipment. The output triggers may be timed to occur either before or after the main output pulse.

Source impedance

Generator source impedance is an important consideration in fast pulse systems. This is because a generator which has a source impedance matched to the connecting cable will absorb reflections resulting from impedance mismatches in the external system. Without this match, reflections would be re-reflected by the generator, resulting in spurious pulses or perturbations on the main pulse.

DC coupling of the output circuit is necessary when retention of dc bias levels in the test circuit is desired in spite of variations in pulse width, pulse amplitude, or repetition rate.

Applications of pulse and square wave generators

Pulse generators with fast risetimes are widely used in the development of digital circuits. Teamed with a fast oscilloscope, these generators enable evaluation of transistor and diode switching times. Very fast rise time pulse generators used with fast oscilloscopes also can measure the stray inductances and capacitance of components.

Variable rise and fall time pulses are invaluable for testing devices whose output changes with rise and fall times, such as magnetic memories. Variable transition time pulses are useful in checking logic circuits where the input signal characteristics must be carefully specified.

Pulse generators are used as modulators for klystrons and other rf sources to obtain high peak power while maintaining low average power.

Pulse generators also are used for impulse testing. A very short pulse is rich in harmonic frequency components, so that impulse testing amounts to simultaneous frequency response testing of components or systems.

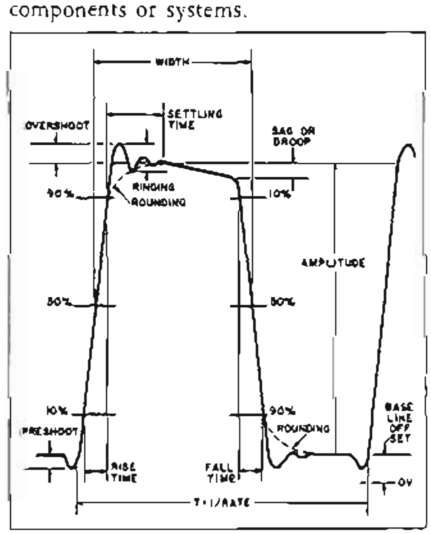


Figure 2. Test pulse description in terms of primary characteristics.

Test of linear systems with pulse or square wave generators and oscilloscopes are dynamic tests which quickly analyze system performance.

Hewlett-Packard designs pulse generators with fast rise times (fixed or variable), matched source impedance, flexible pulse width and amplitude control, and versatile triggering capabilities required by a wide range of measurements. Particular attention has been paid to the quality of the output pulse, with all aspects of pulse shape carefully controlled and specified in detail.

Plug-in pulse generator

The 1900 system provides the optimum in performance at minimum cost by allowing you to select a pulse generator that will control only the pulse parameters required for a particular application. The completely specified high-quality test pulses provide accurate, dependable tests of circuits and components. Another feature is built-in shielding that reduces electro-magnetic radiation and conduction.

Flexibility and compatibility are achieved by having all pulse generator module circuits contained in a plug-in. Mainframes only contain the power supplies and, if desired, optional programming wiring. Plug-in design also provides the equivalent of two or more pulse generators, in laboratory applications, by simply changing plug-ins in a mainframe. In system applications, plug-ins can be selected to fit the exact test requirements and in the event of a malfunction, system downtime is reduced by changing plug-ins instead of the complete pulse generator. This flexibility is illustrated by the block diagram in figure 3.

Optional programming

All major functions in the 1900 system are designed for remote analog or digital

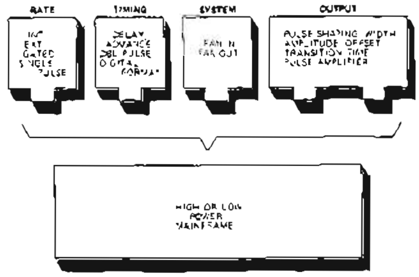


Figure 3. 1900 System Block Diagram.

programming, Analog programming provides semi-automatic testing of components or equipment that require several different repeatable pulse waveforms. Digital programming is provided by the 6940S multiprogrammer which allows control of a large number of pulse parameters with a single, 16 bit parallel computer word. This provides complete control of pulse parameters in a fully automatic test system at minimum cost.

Dedicated pulse generators

The versatile 8000 series pulse generators provide a wide selection of pulse parameter control and repetition rates to meet your testing requirements at the lowest possible cost. These pulse generators offer fixed or variable transition times, maximum rep rates of 10, 50, 100, and 200 MHz, fixed and variable delays, and many other features.

For digital applications, the 8006A word generator provides two 16-bit words or a single 32-bit word. With this versatility in output formats, digital equipment can be fully exercised during design or checkout.

The range of repetition rates in the variable rise-and-fall-time models enable testing of circuits and components under actual operating conditions rather than conditions limited by the pulse generator. Also, rise and fall times can be adjusted to simulate a function generator, providing triangular, sawtooth, and trapezoidal shapes as well as pulses and square waves.

Fixed transition time pulsers are also available for checking fast switching speeds. Long pulse durations (some to 3 seconds) in these pulse generators make them ideal for checking analog devices such as wideband amplifiers, filters, and other linear devices.

For complex waveforms, the 8010A dual-channel pulse generator provides two separate pulse trains with independent control of all pulse parameters except rep rate. The two channels may also be combined without loss of amplitude to form pulses of almost any shape.

Models 8007B (100 MHz) and 8008A (200 MHz) will fill a design engineer's requirements in developing and testing high-speed digital circuits for computers, communications, telemetry, and many other applications. To further increase the usefulness of these pulse generators, they can be operated as a pulse shaper for RZ or NRZ formats which will make them compatible with technology for years to come.

Pulse Generator Selection Chart

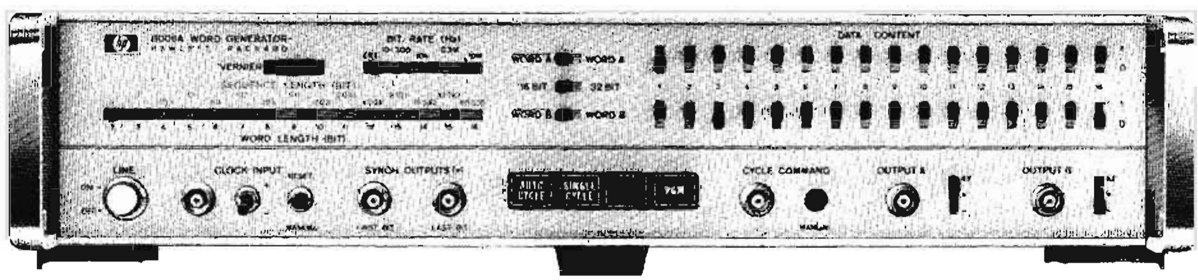
TYPE	SQUARE WAVE		PULSE GENERATORS												DIGITAL	
Model No.	211B	221A	214A	8002A	8003A	8004A	8005A	8007B	8008A	8010A	8012A	8013A	1900*	1900*	8006A	1900*
Max. Rep Rate (MHz)	10/1	10	1	10	10	10	10	100	200	10	50	50	25	125	10	50
Gated Output			●	●	●	●	●	●	●	●	●	●	●	●		
Ext Trigger			●	●	●	●	●	●	●	●	●	●	●	●	●	●
Delay	Fixed		Var	Fixed	Fixed	Var	Var	Var	Var	Var	Var	Var	Var	Var		Var
Output V into 50Ω	—5/—30	+5	±100	±5	5	±5	5	±5	±4	±5	±5	5	±50	±5	5	
Simultaneous Output	—5				+, —		+, —		norm.	●		+, —				
Rise Time (ns)	5/70	15	15	10 —2s	5	1.5	10 to 2s	2.0 to 250 μs	<1.2	10 to 1s	5 to 0.5s	3.5	7 to 1ms	<2 to 250 μs	10	
Double Pulse			●			●	●	●	●	●	Opt	Opt	●	●		
Offset (V into 50Ω)						±2	±2	±4	±2	±2	±2.5	—5, +1 +5, —1	±3	±5		
Digital Formatting															two 16- or one 32- bit word	16- bit word 4⊕Gen
RZ/NRZ Formats (external input, word, PRBS, or bit error detection)								●	●		●	●	●	●	●	●
Price	$490	$240	$1075	$760	$500	$965	$1150	$1750	$2700	$2000	$875	$625	*	*	$1355	*

*Plug-in pulse/digital system, output, risetime, price, and many other parameters vary with plug-ins. Refer to 1900 System selection chart for more details.

WORD GENERATOR

Two channel binary waveform generator

Model 8006A



8006A

The 8006A generates serial digital words of variable length at clock rates up to 10 MHz. An easy selection of two 16 bit words is available. A single action puts the two 16 bit words in series to provide a 32 bit word at each output. Selectable operating modes include positive return-to-zero (RZ) format, positive and negative non-return-to-zero (NRZ) format, manual or automatic word cycling, complementary output signals, and remote programming of the data content. The remote programming feature allows conversion of parallel words to serial words. Two outputs provide trigger pulses coincident with the first and the last bit.

Additionally, a pseudo-random binary sequence variable from 7 to 65535 bits can be obtained from channel A output, with the inverted sequence available at channel B.

Specifications

Word generation: one 4 to 32 bit word (only even number of bits) or two 2 to 16 bit words.

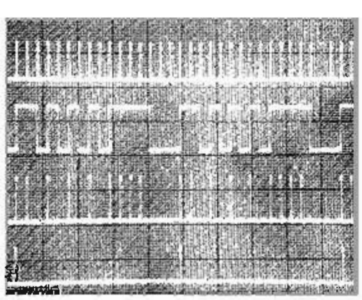
Word content: independently set for both words by front panel switches or remote programming (parallel data input). Complement of each word selectable by front panel switches, WORD A - $\overline{\text{WORD A}}$, WORD B - $\overline{\text{WORD B}}$.

Word cycling: continuous or by cycle command (external trigger or manual).

Bit rate: internal, 10 Hz to 10 MHz, four ranges, continuous adjustment within ranges. Manual or external clock 0 to 10 MHz.

Reset: manual reset of word outputs to bit 1 in AUTO CYCLE mode and to word pause in SINGLE CYCLE mode.

Word format: +RZ/+NRZ/−NRZ selectable for each word output. Positive outputs have current sink capability to drive integrated circuits (TTL/DTL).



1. External clock
2. NRZ Output (16 bit continuous word recycling)
3. RZ Output signal
4. First bit synch pulse

Synch outputs: trigger pulses corresponding to the first bit (leading edge) and last bit (trailing edge).

Pseudo-random sequence generation PRN: provides a linear shift register sequence at channel A output and the inverted sequence at channel B output. Maximum bit rate is 9 MHz.

Sequence length: variable from 7 to 65535 bits.

Trigger pulse: selectable for each bit in sequence.

Interface:

Clock input:

Repetition rate: 0 to 10 MHz, Amplitude: $\geq \pm 2$ V, $\leq \pm 10$ V.

Width: >15 ns at ±1 V. Input impedance: >500Ω.

Cycle command input:

Minimum period: word length plus 100 ns. Amplitude >+2 V. <+10 V.

Width: >15 ns at +1 V. Input impedance: >500Ω.

External data inputs: no storage capability for programmed data.

Low state: contact closure, saturated DTL or voltage source (TTL) >0 V, <+0.8 V.

High state: open, off DTL or voltage source (TTL) >+2.4 V, <+5 V.

Synch outputs:

Amplitude: >+2 V across 50Ω.

Width: approx. 40 ns. Output impedance: 50Ω

Word outputs:

Positive NRZ, RZ: high: +2.5 V across 50Ω, source impedance 50Ω. Low: ≥ -0.3 V, $\leq +0.3$ V, source impedance approx. 0Ω. Current sink capability 80 mA maximum.

RZ pulse width: approx. 45 ns.

Negative NRZ: high: 0 V. low: −5 V across 50Ω, source impedance 50Ω.

Transition times: <10 ns.

General

Operating temperature: 0° to 50°C.

Power: 115 V or 230 V, +10%, −15%, 48 Hz to 440 Hz, 59 VA.

Weight: net 13¼ lbs (6 kg).

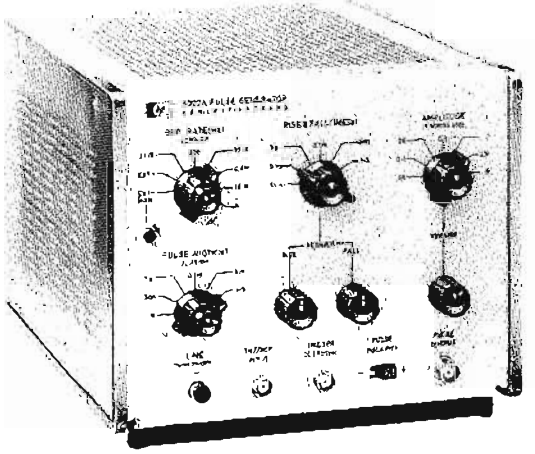
Dimensions: 16¾" wide, 3-15/32" high, 13¼" deep (425.5 x 88.2 x 337 mm).

Price: Model 8006A, $1355

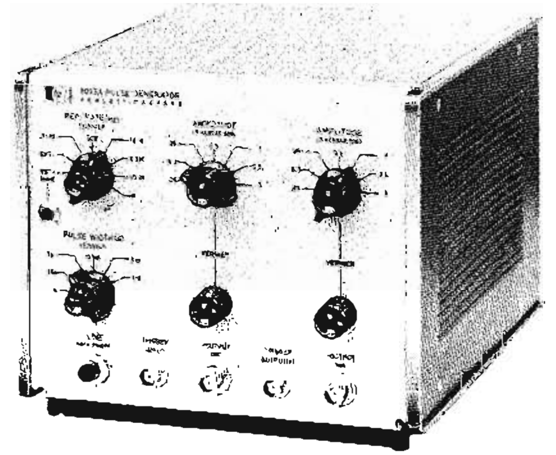
Option 001: rear panel clock output. Amplitude 2 V across 50Ω. Source impedance approx. 50Ω. Pulse width approx. 30 ns. Price: add $30.

Computer Interface kit: Model 12556B and cable 08006-61650.

PULSE GENERATORS
Maximum repetition rate 10 MHz
Models 8002A, 8003A



8002A



8003A

The Hewlett-Packard 8002A generates pulses with variable transition times. All pulse parameters are variable over extremely wide ranges. Indeed, the 8002A is a function generator capable of delivering triangular, sawtooth and trapezoidal shapes as well as pulses and square waves.

Either positive or negative output signals can be selected, the source impedance is a constant 50Ω. Output amplitude is continuously adjustable from 0.02 to 5 volts and can be doubled by switching off the internal 50Ω load. The output is protected against damage from a short circuit.

The generator can be triggered externally with sine waves or pulses of either polarity. A trigger output signal is also available.

The 8003A is a highly flexible dual output general-purpose pulse generator, with fixed transition times of <5 ns; its characteristics are similar to those of the 8002A.

Remote programming of repetition rate, pulse width, and amplitude is offered as an option for the 8003A, making it suitable for use in automatic and semi-automatic test systems.

Specifications

Source impedance: 8002A: 50Ω ±10%. 8003A: 50Ω ±3% shunted by typ. 20 pF.

Pulse characteristics (50Ω source and load impedance):

Transition times:

8002A: 10 ns to 2 s, 6 ranges, ranges are common for both transition times, two verniers allow independent control of leading and trailing edge.

8003A: <5 ns.

Preshoot, overshoot, ringing: <5% of pulse amplitude.

Linearity: 8002A: for transition times >20 ns, maximum amplitude deviation from a straight line between the 10 and 90% points is less than 4% of pulse amplitude.

Amplitude: 5 V max. (10 V across an open circuit). Output circuit protected, cannot be damaged by shorting. Seven-step attenuator reduces output voltage to 0.05 V (positive and negative output independent on 8003A).

Polarity: 8002A: + or − selectable. 8003A: + and − simultaneously within 5 ns.

Pulse width: 30 ns to 3 s in 5 ranges.

Maximum duty cycle: >90% from 0.3 Hz - 1 MHz >50% from 1 MHz - 10 MHz.

Delay: 8002A: 180 ns or 35 ns fixed delay between trigger and pulse. 8003A: 150 ns or 10 ns delay between Trigger Output and both Pulse Outputs.

Repetition rate and trigger:

Free running: 0.3 Hz to 10 MHz, 5 ranges.

Manual: pushbutton for single pulse.

Trigger input: sine waves 2 Vp-p or pulses of either polarity, >1 V up to 10 MHz.

Input impedance: approximately 1 kΩ dc coupled.

External trigger delay: approximately 35 ns between leading edge of external input pulse and the leading edge of trigger output pulse.

Trigger output pulse (suitable for triggering another Model 8002A or 8003A): >+2 V across 50Ω, width 15 ns ±5 ns.

Synchronous gating: gating signal turns generator "on": last pulse is completed even if gate ends during the pulse.

Gate input: −2 V to −20 V enabling.

Input impedance: approximately 1 kΩ, dc coupled.

General

Power: 115 or 230 V +10%, −15%, 50 Hz - 400 Hz, 40 VA (8002A), 30 VA (8003A).

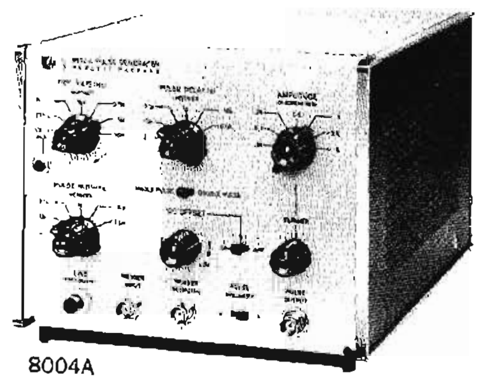
Dimensions: 6-17/32" high, 7-25/32" wide, 11" deep (166 x 190 x 279 mm).

Weight: net, 9 lbs (4 kg); shipping, 11 lbs (5 kg).

Price: Model 8002A: $760. Model 8003A: $500.

Option 001 (8003A only): remote programming. Ranges: rep. rate, width by contact closure to ground. All verniers: by value of external resistor. Add $70.

PULSE GENERATOR
Extremely fast transition times
Model 8004A


8004A

8004A Pulse Generator

The 8004A generates pulses with extremely fast transition times. Pulse width is variable over a wide range. The variable pulse delay can be reduced to zero. A double pulse mode provides convenient test signals for logic and memory circuits. DC offset permits the pulse baseline level to be set up to ±2 V off ground independent of the setting of the pulse amplitude controls.

Specifications

Pulse characteristics (50Ω source and load impedance):
Transition times: <1.5 ns.
Preshoot, overshoot, ringing: <5% of pulse amplitude.
Amplitude: 5 V max. seven-step attenuator reduces output to 0.05 V; continuous adjustment between steps reduces output to <0.02 V. Output shortcircuit proof.
Polarity: + or − selectable.
Source impedance: 50Ω shunted by typ. 10 pF.
DC offset: ±2 V across 50Ω load; independent of atteuator and vernier settings; can be switched off.
Pulse width: 0 to 1 ms in six ranges, Vernier provides continuous adjustment within ranges.
Maximum duty cycle: >50% from 100 Hz to 1 MHz; >25% from 1 to 10 MHz.
Width jitter: <0.1% on any width setting, plus 50 ps.
Pulse delay (with respect to trigger output): 0 to 1 ms in 5 ranges; continuous adjustment within ranges.
Delay jitter: <0.1% on any delay setting.

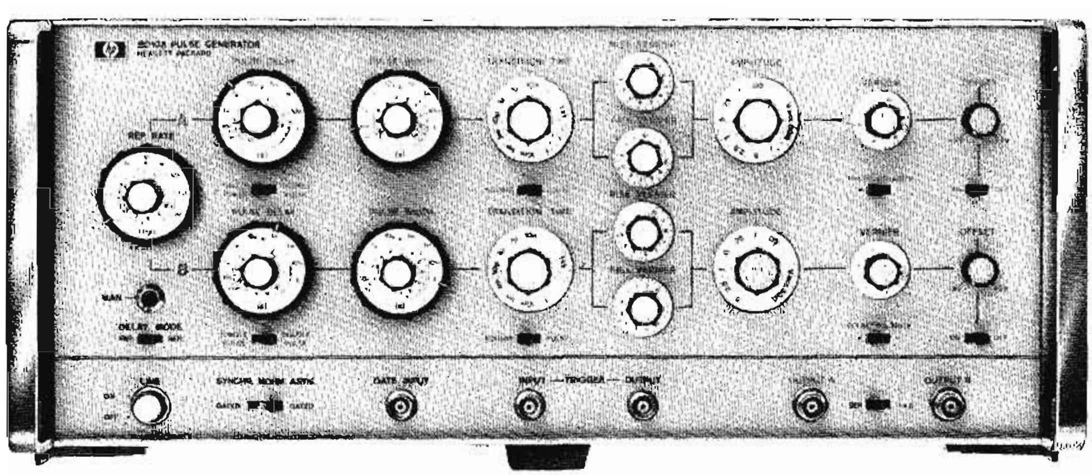
Repetition rate and trigger: same as 8005A except:
Free running: repetition rate: 100 Hz to 10 MHz, five ranges. Vernier provides continuous adjustment.
External triggering: delay: approx. 125 ns between trigger input and trigger output. May be reduced to approx. 35 ns (slide switch on board).
Trigger output width: 15 ns ±10 ns.

Gating: same as 8005A except no A/B gate.

General

Power: 115 or 230 V, +10%, −15%, 50 to 400 Hz, 35 VA.
Weight: net 7 lb (3,5 kg); shipping 9 lb (4,5 kg).
Dimensions: 7¾" wide, 6½" high, 11" deep (197 x 165 x 279).
Price: Model 8004A, $965.

8010A Pulse Generator


8010A

PULSE GENERATORS
Two channels for complex waveforms
Models 8010A

8010A pulse generator

The Model 8010A Pulse Generator offers all the advantages of the 8005A plus additional features. The 8010A comprises two completely separate channels with only the repetition rate common to both. Pulse delay, width, transition times, amplitude, and DC-offset controls are independent for each channel. Most front panel controls are calibrated.

The polarity of each output can be selected individually. Complex wave shapes, of the order shown in Figure 1 are generated by Channels A and B together with the 8010A's combining capabilities. Both channels can also be operated in a square wave mode.

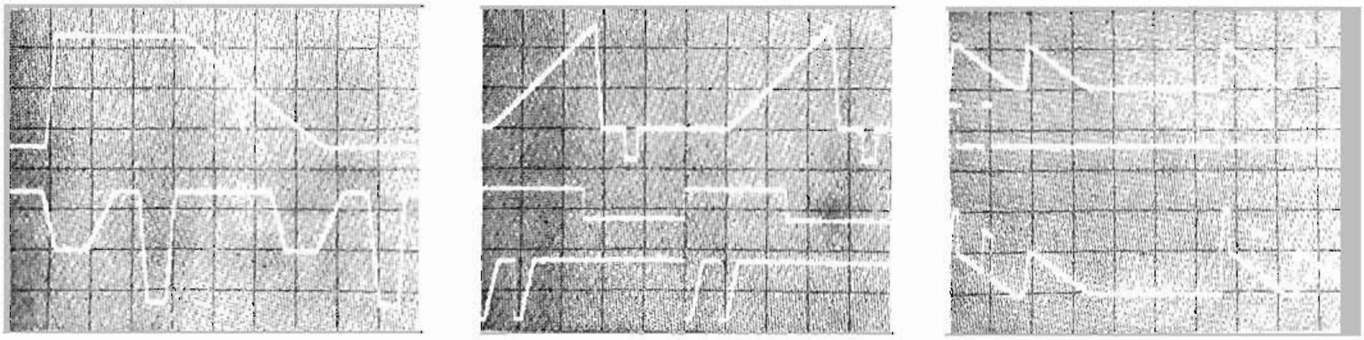


Figure 1. A selection of waveforms showing single and combined outputs.

Specifications

Pulse characteristics (with 50Ω load impedance):

Transition times: sep. outputs: <10 ns to 1 s, eight ranges; ranges are common for leading and trailing edge. Independent verniers provide separate control of leading and trailing edge within each range up to a max. ratio of 1:10.

Common outputs: <12 ns to 1 s.

Accuracy: ±10% of setting ±2% of full scale ±4 ns.

Linearity: for transition time >30 ns maximum amplitude deviation from a straight line between the 10% and 90% points is less than 4% of pulse amplitudes.

Overshoot and ringing: <5% of pulse amplitude.

Pulse width (A and B): <20 ns to 1 s eight ranges, continuous adjustment within ranges.

Accuracy: ±10% of setting ±2% of full scale ±4 ns.

Maximum duty cycle: >90% for repetition rates from 1 Hz to 1 MHz. >50% from 1 to 10 MHz.

Width jitter: <0.1% on any width setting.

Maximum output: 5 V sep. Combined outputs: 10 V channel B (channel A no output).

Attenuator: seven-step attenuator reduces output to 0.05 V, continuous adjustment between steps reduces minimum output to 0.02 V.

Pulse polarity: A and B independently selectable.

Source impedance: 50Ω ±10% shunted by typ. 20 pF.

DC-offset: ±2 V across 50Ω load. Independent of attenuator and vernier setting; can be switched off.

Pulse delay: (A and B) 50 ns to 1 s delay with respect to trigger output. Eight ranges; continuous adjustment within ranges.

Accuracy: ±15% of setting.

Delay jitter: <0.1% on any delay setting.

Repetition rate and trigger:

Free running: 1 Hz - 10 MHz, seven ranges, continuous adjustment within ranges.

Accuracy: ±10% of setting ±2% of full scale.

Period jitter: <0.1%.

Square wave: 1 Hz - 10 MHz. Output symmetrical to ground.

Double pulse: channel A and B independently selectable.

External triggering:

Rep. rate: 0 to 10 MHz. (For square wave output frequency divided by a factor of 2).

Trigger input: sine waves 1 V p-p. Pulses 0.5 V, >20 ns.

Input impedance: 1.0 kΩ.

Delay: approximately 30 ns between trigger input and trigger output.

Manual: pushbutton for single pulse.

Sep. triggering for both channels: +2 V, >50 ns. Input impedance 50Ω (inputs on rear panel).

Trigger output:

Amplitude: > +2 V across 50Ω. 15 ns ±10 ns.

Impedance: 50Ω.

Synchronous gating: gating signal turns rate generator "on".

Asynchronous gating: gating signal turns the output pulse "on". Trigger output always available.

Gate inputs: −2 V to −10 V enabling.

General

Power: 115 or 230 V +10%, −15% 50 to 400 Hz 200 VA.

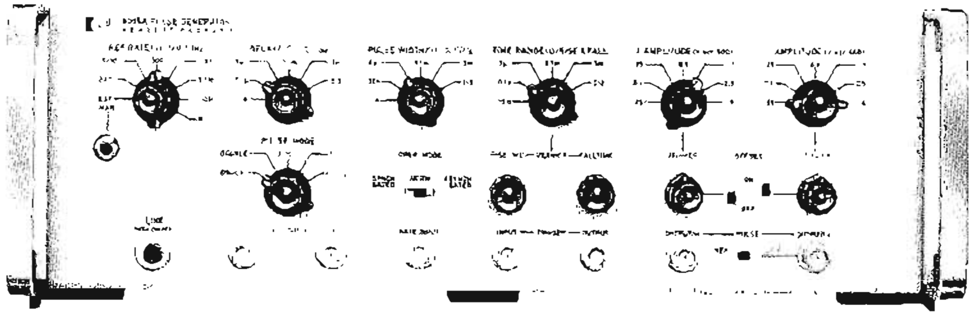
Dimensions: 16¾" wide, 7¼" high, 18⅜" deep (425 x 184 x 466 mm).

Price: $2000.

PULSE GENERATORS

Two channels for complex waveforms

Model 8005A



8005A

8005A pulse generator

With adjustable rise and fall times, variable width and delay features, simultaneous positive and negative outputs that can be combined into a single complex signal, the Model 8005A gives complete control of the output waveform. Both output amplitudes are separately adjustable and dc-offset controls allow independent setting of the baseline. Versatile gating possibilities further enhance the utility of the 8005A. Signals of great complexity can be generated using the A/B delay mode, as illustrated in Figure 1.

Specifications

Pulse characteristics (50Ω source and load impedance):

Transition times: separate outputs: <10 ns to 2 s, six ranges (common for both transition times), independent verniers for leading and trailing edge.

Common outputs: <12 ns to 2 s

Linearity: for transition times >30 ns, maximum amplitude deviation from a straight line between 10 and 90% points is ≤4% of pulse amplitude.

Preshoot, overshoot, ringing: <5% of pulse amplitude.

Pulse width: 30 ns to 3 s in five ranges; continuous adjustment within ranges.

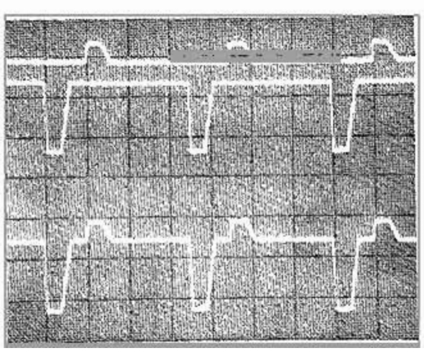


Figure 1. Separate and combined non-simultaneous outputs.

Maximum duty cycle: >90% for repetition rates from 0.3 Hz to 1 MHz; >50% from 1 to 10 MHz.

Width jitter: <0.1% on any width setting.

Amplitude: 5 V maximum (10 V across an open circuit); seven-step attenuator reduces output to 0.05 V; continuous adjustment; minimum output 0.02 V.

Output mode: Sep: + and − pulses available simultaneously or delayed with respect to each other. Delay is variable.

Source impedance: 50Ω ±10% shunted by 20 pF.

DC-offset: ±2 V across 50Ω load; can be switched off.

Pulse delay: 100 ns to 3 s with respect to trigger output; five ranges; continuous adjustment within ranges. Delay jitter: <0.1% on any setting.

Repetition rate and trigger:

Free running: 0.3 Hz to 10 MHz, five ranges; continuous adjustment within ranges. Period jitter: <0.1%.

Double pulse: increases max. rate to 20 MHz.

External triggering: 0 to 10 MHz.

Sensitivity: sine waves 2 V p-p; pulses 1 V peak, >10 ns; maximum input ±10 V. Delay: approx. 35 ns between trigger input and trigger output. Input impedance: approx. 1 kΩ, dc-coupled.

Manual: pushbutton for single pulse.

Trigger output: amplitude >+2 V across 50Ω, 15 ns ±5 ns wide.

Gating:

Synchronous gating: gating signal turns generator "on". Last pulse is completed even if gate ends during pulse.

Asynchronous gating: gating signal turns output pulse "on". Trigger output always available; last pulse ends with gate.

Gate A/B: independent gating signal for each output.

Gate input: −2 V to −20 V enabling.

Input impedance: approx. 1 kΩ, dc-coupled.

General

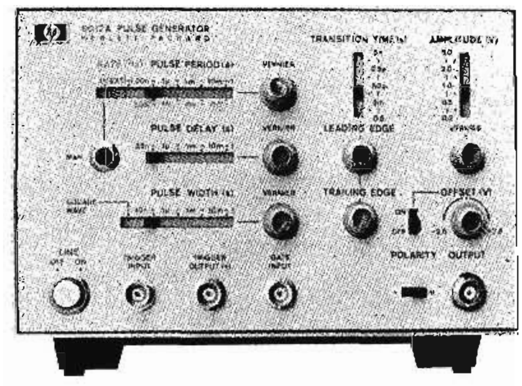
Power: 115 or 230 V, +10%, −15%, 50 to 400 Hz, 84 VA.

Weight: net 16 lb (7 kg); shipping 20 lb (9 kg).

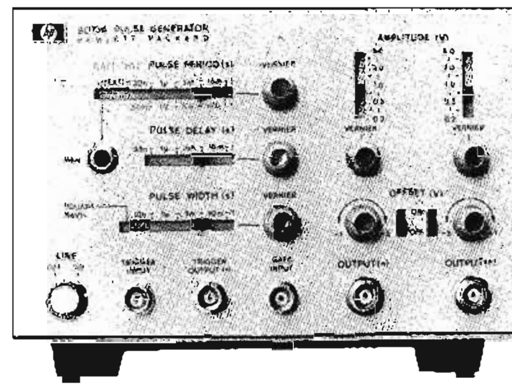
Dimensions: 16¾" wide, 5½" high, 13¼" deep (425 x 140 x 336 mm).

Price: $1150.

PULSE GENERATORS
Repetition rate up to 50 MHz, high flexibility
Models 8012A, 8013A



8012A



8013A

The 8012A and the 8013A are extremely flexible pulse generators with repetition rate, delay, width, amplitude and DC offset variable over very wide ranges.

The 8012A has one output and offers independently variable transition times, ranging from 5 ns to 0.5 s.

The 8013A has two outputs, providing simultaneous pulses of opposite polarity. Transition times are fixed at 3.5 ns.

Both instruments feature external triggering, synchronous gating, square wave mode and pulse shaping capability for RZ and NRZ signals.

Specifications

Pulse characteristics (50Ω source and load impedance):

Transition times: 8012A: 5 ns –0.5 s in four ranges. Ranges common for both transition times, verniers provide separate control of leading and trailing edge within each range up to maximum ratios of 100:1 or 1:100. 8013A: 3.5 ns fixed.

Linearity: (8012A) for transition times >30 ns maximum deviation from a straight line between the 10% and 90% points is 5% of pulse amplitude.

Preshoot, overshoot, ringing: <±5% of pulse amplitude.

Pulse width: <10 ns to 1 s in four ranges. Vernier provides continuous adjustment within ranges.

Width jitter: <0.1% +50 ps on any width setting.

Maximum duty cycle: >75% from 1 Hz to 10 MHz, decreasing to >50% at 50 MHz.

Maximum output: 5 V across 50Ω, (10 V across open circuit). Output circuit protected, cannot be damaged by shorting. 8013A: internal 50Ω load may be disconnected, providing 10 V across 50Ω.

Attenuator: four-step attenuator reduces output voltage to 0.5 V. Vernier provides continuous adjustment between steps. Minimum output 0.2 V.

Polarity: 8012A: positive or negative selectable. 8013A: two outputs, positive and negative.

Source impedance: 8012A: 50Ω ±10% shunted by typ. 20 pF. 8013A: 50Ω ±3% shunted by typ. 20 pF.

DC offset: (across 50Ω load) 8012A: ±2.5 V. 8013A: positive output: +1 V to –5 V, negative output: –1 V to +5 V. Independent of amplitude control settings, may be switched off.

Pulse delay: <35 ns to 1 s (with respect to trigger output), four ranges; continuous adjustment within ranges.

Delay jitter: <0.1% +50 ps on any delay setting.

Repetition rate and trigger: 1 Hz to 50 MHz in four ranges, continuous adjustment within ranges.

Period jitter: <0.1% +50 ps on any rate setting.

Square wave: 0.5 Hz to 25 MHz in four ranges. Duty cycle 50% ±5% up to 1 MHz, tolerance increases to ±15% at 25 MHz.

Trigger output: >+1 V across 50Ω, 16 ns ±10 ns wide. Suitable for triggering another 8012A.

External triggering: 0 to 50 MHz. For square wave output, frequency divided by factor 2.

Trigger input: sine waves 1.5 Vp-p (about zero), pulses 0.8 V, either polarity, >7 ns. Maximum input ±7 V.

Impedance: 50Ω ±10%, dc coupled.

Delay: 25 ns ±8 ns between leading edge of trigger input and trigger output signals.

Manual: pushbutton for single pulse.

Gating:

Synchronous gating: gating signal turns generator "on". Last pulse is completed even if the gate ends during pulse.

Gate input: dc-coupled; voltage at open connector approx. +1.8 V. Shorting current ≤12 mA. Input impedance approx. 160Ω.

Gate input signal: voltage >+1.5 V or resistor >300Ω to ground enables rep. rate generator. Voltage <+0.8 V or resistor <150Ω disables rep. rate generator. Gate input TTL compatible.

Maximum input signal: ±5 V.

External width and RZ:

External width: output pulse width determined by width of drive input signal. Amplitude, transition times selectable.

RZ mode: external drive input switched to delay generator. Period determined by period of drive input signal. Delay, amplitude width, transition times selectable.

Rep. rate generator: provides trigger output independent of external width input signal.

Input signal: >+1 V, >7 ns wide. Maximum ±5 V. Impedance 50Ω, dc coupled.

General

Operating temperature range: 0°C to 55°C.

Power: 115 V or 230 V, +10%, –15%, 48 to 440 Hz, 70 VA max.

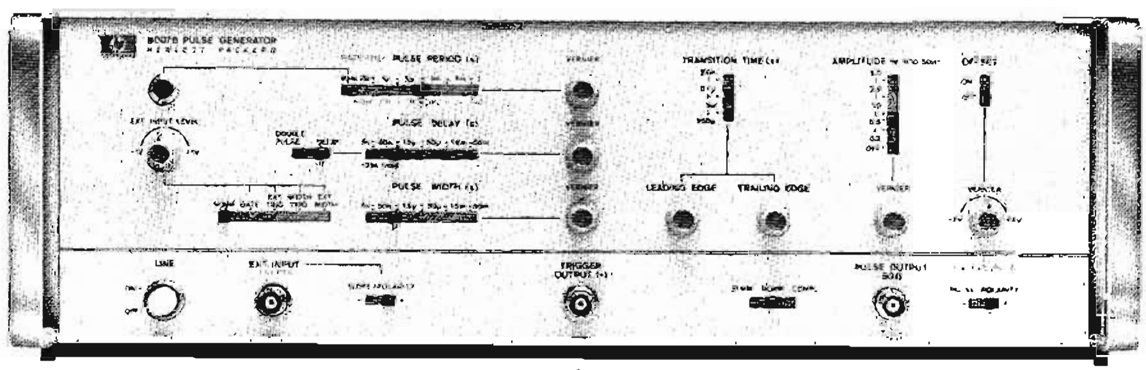
Weight: net, 9 lbs (4 kg); shipping 14.6 lbs (6.5 kg).

Dimensions: 7.9" wide, 5.6" high, 13" deep (200 x 142 x 330 mm).

Price: 8012A, $875. 8013A, $625.

Accessories: 15179A Adapter Frame; rackmount for two units.

PULSE GENERATOR
Repetition rate up to 100 MHz
Model 8007B



NEW

8007B

The 8007B is a versatile pulse generator with very fast variable transition times of 2 ns min.

The output can be set to positive or negative polarity, complement or symmetrical to ground, square waves can be simulated by adjusting pulse width and transition time. Variable dc-offset of ±4 V is also available.

In "External Width" mode drive input and output pulse have equal width. Transition times and amplitude of the output pulse can be set by the front panel controls. This mode is useful for shaping NRZ signals, as the width information is passed on to the output pulse unchanged.

The "Width Trigger" mode is suitable for shaping RZ signals. Delay, width, transition times and amplitude are determined by the front panel controls.

External triggering and synchronous gating are provided. The trigger level is adjustable for all externally controlled modes with the slope polarity selectable. This is very useful to avoid mulfunction caused by noise and ringing on the external trigger signal.

Specifications

Pulse characteristics (50Ω source and load impedance):

Transition times: <2 ns to 250 μs, three ranges (common for both transition times). Independent verniers for adjusting leading and trailing edge within each range up to maximum ratios of 1:50 or 50:1.

Linearity: Maximum amplitude deviation from a straight line between 10% and 90% points ≤5% of pulse amplitude.

Preshoot, overshoot, ringing: <±5% of pulse amplitude.

Pulse width: <5 ns to 50 ms in five ranges. Vernier provides continuous adjustment within ranges.

Width jitter: <0.1% on any width setting.

Maximum duty cycle: normal >50%; complementary approx. 100%.

Amplitude: 5 V max. (10 V across an open circuit); four-step attenuator reduces output voltage to 0.5 V. Vernier provides continuous adjustment between steps and reduces output to 0.2 V. Pulse can be switched off for offset adjustment.

Pulse output: + or − polarity selectable: normal, complement, or symmetrical to ground.

Source impedance: 50Ω ± 4Ω shunted by typ. 10 pF.

DC-offset: ±4 V across 50Ω load. Independent of amplitude setting, can be switched off.

Pulse delay: <30 ns to 50 ms with respect to trigger output. Five ranges, with continuous adjustment within ranges.

Delay jitter: <0.1% on any delay setting.

Repetition rate and trigger: 10 Hz to 100 MHz in five ranges. Continuous adjustment within ranges.

Period jitter: <0.1%.

Double pulse: available only up to pulse rate setting of 50 MHz, representing an ouput pulse rate of 100 MHz.

Trigger output: > +1 V across 50Ω, 4 ns ± 2 ns wide.

External triggering: 0 to 100 MHz.

Delay: approximately 15 ns between trigger input and trigger output.

Manual: front panel pushbutton for single pulse.

External width and Width trigger:

External width: output pulse width determined by width of drive input.

Width trigger: external drive input switched to the width generator. Pulse width determined by front panel width setting.

Rate generator: provides trigger pulses independent of drive input.

Synchronous gating: gating signal turns generator "on". Last pulse is completed even if gate ends during pulse.

External input: impedance: 50Ω, dc-coupled. Max. input: ±5 V.

Level: adjustable from +1 V to −1 V. Polarity: + or −.

Sensitivity: sine waves 1 V pp; pulses ±0.5 V.

General

Operating temperature range: 0°C to +55°C.

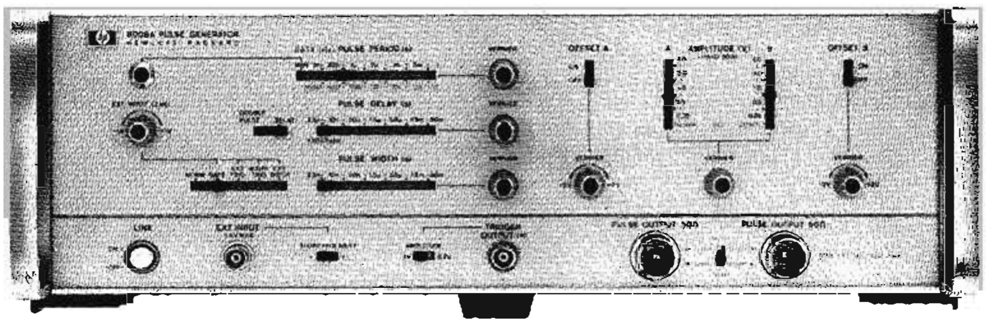
Power requirements: 115 or 230 V +10%, −15%, 48 to 440 Hz, 100 VA (maximum).

Weight: net 17.6 lb (8 kg), shipping 19.8 lb (9 kg).

Dimensions: 16¾" wide, 5½" high, 13⅜" deep (425 x 140 x 344 mm).

Price: $1750.

PULSE GENERATOR
Repetition rate up to 200 MHz, two outputs
Model 8008A



8008A

The Model 8008A is an extremely fast pulse generator with pulse transition times <1.2 ns and repetition rate variable from 10 Hz-200 MHz. Optional risetime converters enable adjustment of transition times up to 2.50 ns.

The two outputs deliver simultaneously complementary signals with selectable polarity. To absorb external reflections, both outputs have constant 50Ω source impedances. A feature of the 8008A is that ECL compatible outputs (high −0.9 V, low −1.7 V) can be selected without tedious adjustment of amplitude and offset controls. This feature and the maximum output amplitude of 4 V with up to ±2 V dc offset ensures compatibility with the majority of logic integrated circuits.

The 8008A can be operated as a pulse shaper for RZ and NRZ format input signals. Similarly, external gating and triggering are possible. The trigger level for any external input signal can be adjusted between +1 V and −1 V on either a positive or negative slope.

Specifications

Pulse characteristics (50Ω source and load impedance)

- **Fixed transition times:** 10%-90%; ≤1.2 ns; 20%-80%; ≤0.9 ns.
- **Overshoot and ringing:** ≤±5% of pulse amplitude (may increase to ≤10% with amplitude vernier ccw).
- **Preshoot:** ≤5% of pulse amplitude.
- **Pulse width:** <2.5 ns to 50 ms in six ranges. Vernier provides continuous adjustment within ranges.

Width Jitter: <0.1% +50 ps on any width setting.

- **Maximum duty cycle:** >50% (in NORM mode).
- **Pulse delay:** 2.5 ns (+30 ns fixed) to 50 ms (with respect to trigger output) in six ranges. Vernier provides continuous adjustment within ranges.
- **Delay jitter:** <0.1% +50 ps on any delay setting.
- **Maximum variable delay:** ≥50% of pulse period.
- **Pulse output:** normal and complement available simultaneously. Output polarity selectable.
- **ECL compatible output:** fixed pulse levels from both outputs. −0.9 V to −1.7 V. Both levels internally adjustable.
- **Maximum amplitude:** normal and complementary; 4 V into 50Ω (8 V across open circuit).
- **Source impedance:** 50Ω ±5% shunted typically 10 pF.
- **Output protection:** cannot be damaged by application of external voltage ≤±8 V (at 25°C) or short circuit, independent of control settings.
- **Attenuator:** two separate four-step attenuators reduce the outputs to 0.5 V. Vernier provides continuous adjustment between steps to <250 mV. Vernier is common to both output channels.
- **DC offset:** ±2 V across 50Ω. Independent of amplitude attenuator and vernier settings. Can be switched off.

Repetition rate and trigger

- **Repetition rate:** 10 Hz to 200 MHz in six ranges. Vernier provides continuous adjustment within ranges.
- **Double pulse:** 100 MHz max. (simulates 200 MHz).
- **Period jitter:** <0.1% +50 ps on any period setting.
- **Trigger output:** amplitude; 1 V or 200 mV (switchable) into 50Ω load.
- **Width:** typically; 3 ns at 200 MHz increasing to 1.5 ms at 10 Hz.

Externally controlled operation

External input

- **Input impedance:** 50Ω (typically).
- **Coupling:** dc coupled.
- **Maximum input:** ±5 V.
- **Trigger level:** continuously adjustable +1 V to −1 V.

External triggering

- **Repetition rate:** 0 to 200 MHz.
- **Delay:** approximately 15 ns between trigger input and trigger output.
- **Manual:** front panel pushbutton for single pulse.
- **Width trigger:** external drive input switched to delay generator. Pulse width determined by width setting. Trigger output available from rate generator independent of input signal.
- **External width:** output pulse width determined by width of drive input. Trigger output available from rate generator independent of input signal.
- **Synchronous gating:** gating signal turns generator "on." First pulse is delayed (by fixed and variable delay) with respect to leading edge of gate, last pulse is of normal width even if gate ends during the pulse. Repetition rate, width, amplitude and polarity determined by control settings.

General

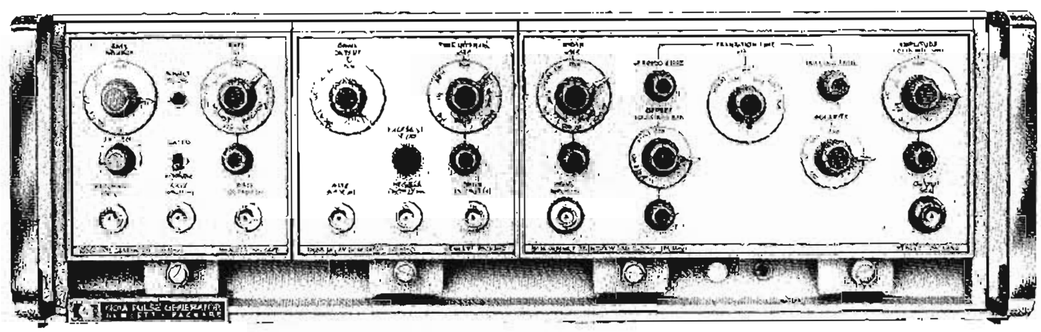
- **Operating temperature range:** 0°C to 55°C.
- **Power:** 115 V or 230 V, +10%, −15%, 48-440 Hz, 100 VA max.
- **Weight:** net, 17.6 lbs (8 kg): shipping, 19.8 lbs (9 kg).
- **Dimensions:** 16¾" wide, 5½" high, 13¼" deep (425 mm x 140 mm x 336 mm).

Ordering information

- **Price:** 8008A, Pulse Generator, $2700.
- **Price:** 8008A Option 001, 8008A + Risetime Converter, $2900

PLUG-IN PULSE GENERATOR

Model 1900 system



1901 Mainframe

Introduction, 1900 Series

The 1900 series provides you with a precision pulse source for every requirement—now and in the future. The plug-in concept allows you to select only the functions you require while enabling future adaptation or expansion at minimum cost.

The series comprises two mainframes and a range of sixteen plug-in modules. The 1900A and 1901A mainframes contain the power supplies and compartments for the plug-in modules. Model 1900A is the base for high power pulse systems while Model 1901A provides the base for medium power systems. Complex systems can be formed by using several mainframes and the desired plug-ins. The internal wiring of a mainframe permits the choice of external or internal interconnection of plug-ins. Another feature is built-in shielding to minimize RFI.

Of the sixteen plug-in modules, two are devoted to rate generation, six to timing and information (e.g. delay, word generation, PRBS generation) and eight to interfacing and output. This comprehensive range enables a vast number of configurations to be constructed varying from the simple pulse shaper to the most complex of test systems. For example, if you already have a trigger source and only need pulse shaping capability, a mainframe equipped with output plug-ins may be all that is necessary for your application. On the other hand, one rate generator may be used to drive several modules through a fan-out amplier, the resulting system providing several pulse sources each with independently variable characteristics.

Rate generators

There are two rate modules in the 1900 series, one covering the range 25 Hz to 25 MHz and the other covering the range 10 Hz to 125 MHz.

Both feature external triggering and synchronous gating capability.

Delay generators

There are three delay generators in the 1900 series. In the 0 to 25 MHz range, the 1908A provides advance and delay of 15 ns to 10 ms. In the 0 to 125 MHz range, the 1909A provides continuously variable delay up to 1 ms and the 1910A provides incrementally variable delay up to 100 ns. Also, 1908A and 1909A offer double pulse and 1909A offers a gating signal output.

Formatting

Applications that require formats are also filled by the 1900 series. The 1925A can generate a 2 to 16 bit word in RZ or NRZ format, or PRBS signals at clock rates up to 50 MHz. Also in the 0 to 50 MHz range is a 4 phase clock generator 1934A which features a selectable phase pattern. The 1930A provides bit error detection, random signal simulation, and coding and decoding functions in the 0 to 40 MHz range.

Output

The output pulse shaping modules control the width, transition times, polarity, offset and amplitude of the test pulses. The modules cover high and low voltage and fixed or variable transition time requirements.

Optional programmability

All the major functions of the 1900 series are designed for remote analog programming. This permits semi-automatic testing where several different pulse waveforms are required. This economical programming facility can be ordered as a factory installed option or an easily installed programming kit.

For complete automatic control, digital programming is available for seven of the plug-ins. Using a 6940A Multiprogrammer as an interface between a 1900 series pulse generator and a minicomputer, efficient and reliable control of a large number of pulse parameters is possible. Another advantage is that up to 240 separate parameters can be controlled from one computer I/O slot. For more information see the Programming description.

PLUG-IN PULSE GENERATOR

Model 1900 system

1900 PULSE GENERATOR SYSTEM

SYSTEM CLOCK (Rate)	INFORMATION (Timing)	INTERFACE (Output)	MAX REP RATE
1900 Mainframe		1915A* 50V/7ns, var 1 output	
1901 Mainframe			
1905A* 25 Hz – 25 MHz	1908A* continuously var. delay	1917A* 10V/7ns, var 1 output; 1920A* 5V/350ps, fxd 1 output	25 MHz
	1930A** PRBS, coding error rate		40 MHz
	1925A** 1 x 16 bit PRBS; 1934A** 4 x 4 bit + continuously var. delay		50 MHz
		1916A 5V/2.5ns, var 2 outputs	100 MHz
		1921A* +5V/2ns, fxd 1 output; 1922A* −5V/2ns, fxd 1 output	
	1909A* continuously var. delay	1927A 8 inputs 1 output	125 MHz
1906A* 10 Hz – 125 MHz	1910A incrementally var. delay	1928A 1 input 8 outputs	

* Optionally Programmable
** Programming standard

Programming requires an Option 001 mainframe

Mainframe specifications, 1900A and 1901A

Plug-in compatibility

For a given combination of plug-ins, add up the applicable percentages of each column. The configuration is compatible when no column exceeds 100%.

Plug-in	Mainframe Space	1900A Power			1901A Power		
		+25 V	−25 V	−10 V	+25 V	−25 V	−10 V
1905A	25%	9%	9%		6%	6%	
1906A	25%	11%	12%		8%	8%	
1908A	25%	8%	8%		6%	6%	
1909A	25%	4%	4%		4%	3%	
1910A	25%	4%	4%		4%	3%	
1915A	50%	27%	25%		–	–	
1916A	50%	41%	43%	7%	27%	30%	5%
1917A	50%	40%	38%		27%	25%	
1920A	50%	55%	55%		36%	36%	
1921A	25%	43%	21%		28%	14%	
1922A	25%	26%	38%		17%	25%	
1925A	25%	10%	2%	38%	6%	2%	25%
1927A	25%	2%	2%		2%	2%	
1928A	25%	28%	19%		18%	12%	
1930A	25%	13%	5%	42%	8%	4%	30%
1934A	25%	20%	7%	25%	14%	5%	17%

Internal interconnection of plug-ins: mainframe contains cables to provide connections between plug-ins. Cable connections may be changed for any combination of plug-in interconnection. Internal or external plug-in interconnection is selected by switches in plug-ins.

General

Dimensions: 16¾" wide, 5¼" high, 21⅜" deep over-all (425 x 133 x 543 mm); 19⅜" (492 mm) behind rack mount.

Weight: 1900A, net, 35 lbs (16 kg); shipping, 46 lbs (21 kg); 1901A, net, 28 lbs (12,7 kg); shipping, 39 lbs (17,6 kg).

Power: 115 or 230 V ±10%, 48 to 66 Hz, 300 watts max. in 1900A and 250 watts max. in 1901A (varies with plug-ins).

Accessories furnished: rack mounting tabs and power cord.

Price

1900A: high power mainframe, $850.

1901A: general purpose mainframe, $565.

Options

001: provides internal cabling and connectors from plug-ins to rear panel for digital or analog programming. Price, add $175.

002: non-pivoting chassis slides with adjustable length of 20 to 22 inches. Price, add $90.

Accessories

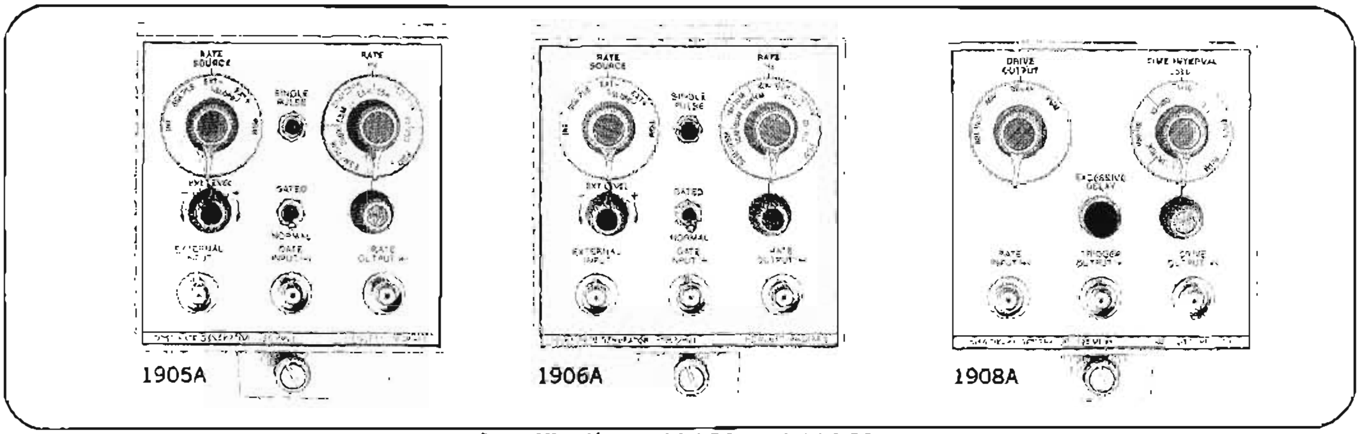
Analog programming kit (HP P/N 01900-69502): provides field installation of Option 001. Price, $175

Chassis slide kit (HP P/N 01900-69501): allows installation of non-pivoting slides with an adjustable length of 20 to 22 inches. Price, $90.

Blank plug-ins: blank plug-ins fill unused plug-in compartments to provide proper plug-in cooling and reduce RFI. Model 10481A, quarter-size plug-in. Price, $25; Model 10482A, half-size blank plug-in, $30.

Plug-in extender: provides access to components when servicing and calibrating an operating plug-in. Extender accommodates both quarter- and half-size plug-ins. Model 10484A plug-in extender. Price, $135.

RATE AND DELAY PLUG-INS
25 MHz and 125 MHz rep. rates, 15ns-10ms delay
Models 1905A, 1906A, 1908A



Specifications, 1905A and 1906A

(Except as noted, specifications apply to both rate generators.)

Frequency

Internal: 1905A, 25 Hz to 25 MHz in 6 ranges; 1906A, 10 Hz to 125 MHz in 8 ranges. 10:1 vernier allows continuous adjustment over selected range.

External: 1905A, 0 to 25 MHz; 1906A, 0 to 125 MHz.

Period jitter: <0.1% of selected period.

External trigger

Amplitude: 1905A, 0.5 V p-p min., 5 V p-p max.; 1906A, 0 to 50 MHz, 0.5 V p-p min; 50 to 125 MHz 1.5 V p-p min. Maximum input, 5 V p-p.

Slope: positive or negative (selectable).

Trigger level: selectable on input waveform from 0 to ±3 V.

Delay: 1905A, approx. 27 ns between external input and rate output; 1906A, approx. 12 ns between external input and rate output.

Input impedance: approx. 50 ohms, dc-coupled.

Synchronous gating

Amplitude: 1905A, −2 V gates generator on, −5 V max.; 1906A, +1 V gates generator on, +5 V max.

Input impedance: approx. 50 ohms, dc-coupled.

Output pulse

Impedance: approx. 50 ohms, dc-coupled.

Amplitude: >1.5 V into 50 ohms (drives two 1900 series plug-ins).

Rise time: 1905A, <5 ns; 1906A, <3 ns.

Width: 1905A, <10 ns; 1906A, <5 ns.

General

Weight: net, 1¼ lbs (0,6 kg); shipping, 6 lbs (2,7 kg).

Price

1905A: 25 MHz Generator, $215.

1906A: 125 MHz Rate Generator, $275.

Options

001: analog programming. Provides connector and circuit card for control of Rate Source (INT, EXT, +, −) and pulse rate. Price: 1905A/6A Option 001, add $100.

005: (1905A only) digital programming. Provides digital control of Rate Source and Pulse Rate. Refer to 1900/6940A description or contact your Helwlett-Packard Field Engineer for more information.
Price: 1905A Option 005, add $500.

Accessories

Programming kit: HP Part No. 01905-69501, provides for field installation for Option 001.

Price: $100.

Specifications, 1908A

Time interval (between Trigger and Drive Outputs)

Range: 15 ns to 10 ms in 6 ranges. 10:1 vernier provides continuous adjustment in any range.

Jitter: <0.1% of selected time interval.

Excessive delay light: indicates that selected delay time exceeds pulse period.

Rate input

Repetition rate: 0 to 25 MHz.

Amplitude: >1.5 V peak min., 5 V peak max.

Maximum delay after rate input (with delay control set to minimum)

Trigger output: approx. 14 ns in delay mode; approx. 29 ns in advance mode.

Drive output: approx. 29 ns in delay mode; approx. 14 ns in advance mode.

Input impedance: approx. 50 ohms, dc-coupled.

Trigger and drive outputs

Output impedance: approx. 50 ohms.

Amplitude: >1.5 V into 25 ohms (drives two 1900 series plug-ins).

Risetime: <5 ns.

Width: <10 ns.

General

Weight: net, 1¼ lbs (0,6 kg); shipping, 6 lbs (2,7 kg).

Price: Model 1908A, Delay Generator, $215.

Options

001: analog programming. Provides connector and circuits for control of Drive Output (Delay, Double Pulse) and Time Interval. Drive Output modes and Time Interval ranges are selected by contact closure to ground. Time Interval vernier is controlled by analog current.
Price: Option 001, add $100.

005: digital programming. Provides digital control of Drive Output (Delay, Double Pulse) and Time Interval. Refer to 1900/6940A description or contact your Hewlett-Packard Field Engineer for more information.
Price: 1908A Option 005, add $500.

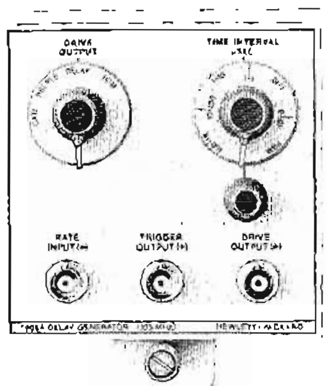
Accessories

Programming kit: HP Part No. 01908-69501 provides for field installation for Option 001.

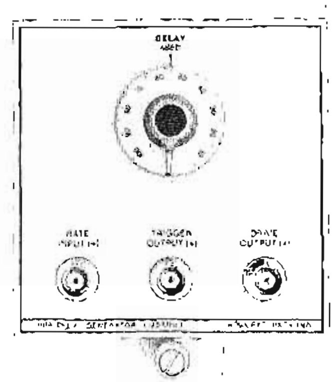
Price: $100.

DELAY GENERATORS
125 MHz variable and incremental delay
Models 1909A, 1910A

NEW▶



1909A



1910A

- 0 to 125 MHz Rep Rate
- Delays from 0 to 1 ms
- Double Pulse
- Gating Pulses from 8 ns to 1 ms

- 0 to 125 MHz Rep Rate
- 5 ns to 100 ns Delay
- Delay Regardless of Rep Rate
- $<$10 ps Jitter

Specifications, 1909A

Time Interval

Delay range: 0 to 1 ms in 6 ranges, 10:1 vernier gives continuous adjustment within ranges.
Double and gate pulse ranges: 8 ns to 1 ms in 6 ranges, 10:1 vernier gives continuous adjustment within ranges.
Jitter: $<$25 ps plus 0.1% of pulse delay.
Time intersymbol interference: delay change with rep. rate typically $<$1.5 ns plus 2% of delay.

Rate Input

Repetition rate: 0 to 125 MHz in delay mode; 0 to 65 MHz in double pulse and gate modes.
Input impedance: 51Ω ±1Ω, dc coupled.
Sensitivity 0 to 125 MHz: amplitude, $\geq$1.5 V; width, $\geq$3 ns; slope, approx 0.2 V/ns at 0.7 V.
Sensitivity 0 to 25 MHz: amplitude, $\geq$1 V; width, $\geq$6 ns; slope approx 0.4 V/ns at 0.7 V.

Drive output

Amplitude: $\geq$1.5 V into 25Ω (drives two 1900 series plug-ins), $\geq$2.5 V into 50Ω in gate mode.
Width: $<$4 ns delay, double pulse modes.
Minimum propagation delay: approx 16 ns with respect to rate input.

Trigger output

Amplitude: $>$1.5 V into 25Ω (drives two 1900 series plug-ins).

General

Weight: net, 1¾ lb (0,6 kg); shipping, 6 lb (2,7 kg).
Price: Model 1909A Delay Generator, $325.
Options
  001: analog programming. Provides connector and circuits to control Drive Output and Time Interval.
  Price: Option 001, add $100.

Specificiations, 1910A

Time Interval (from Trigger Output to Drive Output)

Range: 5 ns to 100 ns in 5 ns increments.
Jitter: $<$10 ps.

Rate Input

Repetition rate: 0 to 125 MHz.
Amplitude: 0 to 25 MHz; 1 V peak min, 5 V peak max. 25 MHz to 125 MHz; 1.5 V peak min, 5 V peak max.
Maximum delay after rate input (with delay control set to min):
  Trigger output: approx 5 ns.
  Drive output: approx 10 ns.
Input impedance: approx 50 ohms, dc coupled.

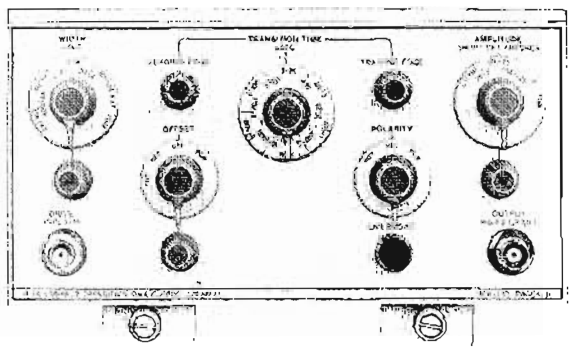
Trigger and drive outputs

Output impedance: approx 50 ohms.
Amplitude: $>$1.5 V into 25 ohms.
Risetime: $<$3 ns.
Width: $<$5 ns.

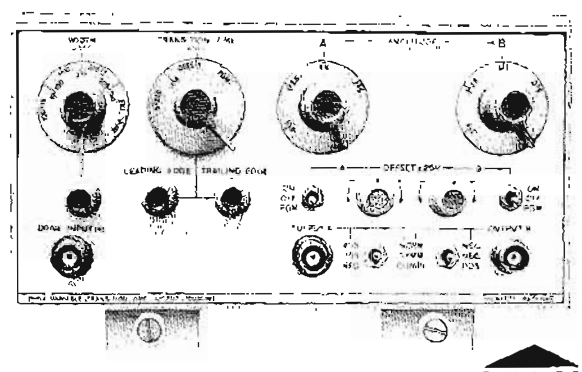
General

Weight: net, 2½ lbs (1,13 kg); shipping, 4¾ lbs (2,2 kg).
Price: Model 1910A, Delay Generator, $225.

OUTPUT PULSE SHAPING
25 MHz high power, 100 MHz variable risetime
Models 1915A, 1916A



1915A



1916A

NEW

Specifications, 1915A

Output pulse

Source impedance: 50 ohms or high impedance: self contained 50 ohm termination can be disconnected.

High impedance output: approx. 4 kohm shunted by <45 pF.

50 ohm output: approx. 50 ohms shunted by <45 pF.

Amplitude (short-circuit current): 50 mA to 1 A in 4 ranges, 2.5:1 vernier allows continuous control within ranges. Voltage into external 50 ohms is ±2.5 V to ±50 V with high impedance source or ±1.25 V to ±25 V with 50 ohm source. Maximum amplitude (including offset) is ±50 V.

Pulse shape

Pulse top variations: 50 ohm source and 50 ohm load, ±5% for transition times 7 ns to 20 ns, ±2% for transition times >20 ns; high impedance source and 50 ohm load, ±5% for all transition times.

Transition times: 7 ns (10 ns with high Z source) to 1 ms in 11 ranges (1, 2, 5 sequence), two 100:1 verniers provide independent control of rise and fall times. Transition time variations over entire amplitude range (±0.2 V to ±25 V): ±15%, ≥100 ns; ±40%, 7 ns to 100 ns.

Polarity: positive or negative, selectable.

Baseline offset: ±60 mA, max. offset into external 50 ohms is ±1.5 V with 50 ohms source. ±3 V with high Z source.

Width

Internal: 15 ns to 40 ms in 7 decade ranges (except first range—15 ns - 40 ns), 10:1 vernier provides continuous adjustment within ranges; width jitter <0.5% of selected width.

External: provides pulse amplifier operation: output pulse width determined by drive input width.

Duty cycle: >65% on all ranges except >50% on 0.015 to 0.04 μs width range; 0 to 100% in external mode. For <0.2% duty cycle operation, refer to overload specification.

Overload

Overload lamp lights to indicate when power detector protection circuits are turning off the output current to prevent damage to the output transistors. The power detector is energized for single pulse or <0.2% duty cycle operation for pulse widths >1 μs. If single pulse or low duty cycle operation is required, Option H15 or, in programmable (005) versions, H51 may be ordered.

Drive Input

Repetition rate: 0 to 25 MHz (see overload specification for low rep. rate considerations).

Amplitude: 1 V peak min., 5 V peak max.

Input impedance: 50 ohms, dc-coupled.

Maximum delay: (after drive input) <45 ns.

General

Weight: net, 5½ lb (2,5 kg); shipping, 9 lb (4,1 kg).

Price: Model 1915A Variable Transition Time Output, $1700.

Options

001: analog programming. Provides connector and circuits to control width, transition time, amplitude, polarity and offset. Price: Option 001, add $275.

002: positive output. Provides positive-only pulse output and positive-only offset. Price: Option 002, deduct $225.

003: negative output. Provides negative-only pulse output and negative-only offset. Price: Option 003, deduct $225.

004: voltage calibration. Calibration of pulse amplitude in voltage. Price: Option 004, add $25.

005: digital programming. Provides digital control of Width, Transition Time, Amplitude, Polarity and Offset. Refer to 1900/6940A description or contact your Hewlett-Packard Field Engineer for more information. Price: Option 005, add $2750.

Accessories

Programming kit: HP Part No. 01915-69501, provides field installation of Option 001. Add $275.

Specifications, 1916A

Pulse characteristics: (50 Ω source and load impedance).

Transition times: 2.5 ns to 250 μs in 3 ranges; 50:1 verniers provide separate control of rise and fall times. Nonlinearity; maximum deviation from straight line between 10% and 90% amplitude, less than 5% of pulse amplitude.

Overshoot, ringing and preshoot: <5% of pulse amplitude.

Amplitude: <200 mV to 5 V (across 50 Ω) in four ranges. Vernier provides continuous adjustment within ranges.

Pulse output: channel A; pos-normal, pos-symmetrical (about offset voltage) or neg-complement. Channel B; neg-normal, neg-symmetrical or pos-complement. Switch selectable.

Maximum duty cycle: >50% for internal width; up to 100% with complement; up to 100% for external width.

Source impedance: 50 Ω ±4 Ω shunted by 10 pF (typ.).

DC offset: ±2.5 V across 50 Ω, independent of amplitude. Can be switched off.

Pulse width: 5 ns to 1 ms in 6 ranges. 10:1 vernier provides continuous adjustment within ranges.

Width jitter: <0.1% + 25 ps of pulse width.

External width: pulse width within ±2 ns of external input width when input width measured at 0.6 V.

Drive Input

Repetition rate: 0 to 100 MHz.

Input impedance: 50 Ω, dc coupled.

Pulse shape: amplitude, >1.5 V; width >3 ns; slope, >0.25 V/ns in internal width, >0.15 V/ns in external width (smaller slopes may cause performance degradation).

Maximum input: ±5 V.

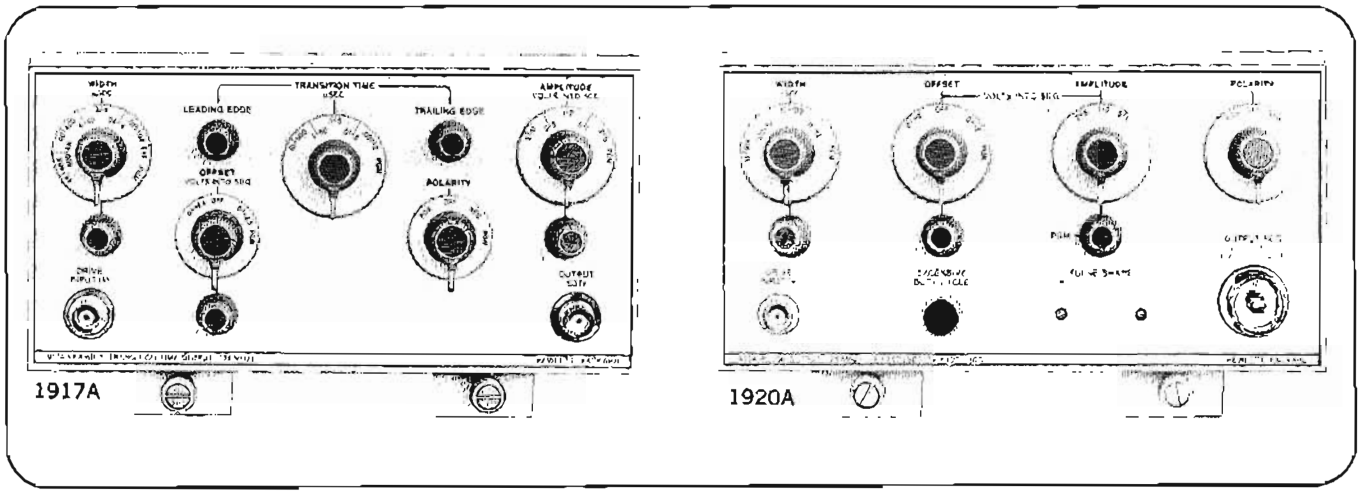
Propagation delay: internal width mode, 23 ns approx; external width mode, 18 ns approx.

General

Weight: net, 2½ lb (1,13 kg); shipping, 6¼ lb (2,8 kg).

Price: Model 1916A Variable Transition Time Output, $1290

OUTPUT PULSE SHAPING
General purpose and fast risetime
Models 1917A, 1920A



Specifications, 1917A

Output pulse

Source impedance: 50 ohms or high Z; selected with internal switch. High impedance output, approx. 3 k ohms shunted by 45 pF; 50 ohms output, approx. 50 ohms shunted by 45 pF.

Amplitude: (volts into 50 ohms) 0.2 to 10 V with 50 ohms source; 0 to 14 V (8 to 400 mA) with 3000 ohms source; 2.5:1 vernier provides continuous adjustment over each range.

Pulse shape

Pulse top variations: ±5% for transition times >7 ns.

Transition times: 7 ns to 500 μs in 5 ranges; two 50:1 verniers provide independent control of rise and fall times. Transition time variations over entire amplitude range (±0.2 to +10 volts): ±15%, ≥100 ns; ±40%, 7 to 100 ns.

Polarity: plus or minus, selectable.

Baseline offset: ±2.5 V into external 50 ohms with 50 ohm source; 100 mA with 3000 ohm source.

Width

Internal: ranges, 15 ns to 40 ms in 7 ranges; 10:1 vernier provides continuous adjustment over each range; width jitter, <0.25% of selected pulse width.

External: provides pulse amplifier operation; output pulse width determined by width of drive input.

Duty cycle: internal width mode, 65% except for 15 to 40 ns width range. 50% on 15 to 50 ns width range; external width mode, up to 100%; limited by output pulse transition times.

Drive input

Repetition rate: 0 to 25 MHz.

Input impedance: 50 ohms, dc-coupled.

Amplitude: 1 V peak min., 5 V peak max.

Maximum delay after drive input: approx. 35 ns.

General

Weight: net, 2½ lbs (1,13 kg); shipping, 6¼ lbs (2,8 kg).

Price: Model 1917A, Variable Transition Time Output, $595.

Options

001: analog programming. Provides connector and circuits to control Width, Transition Time, Amplitude, Polarity, and Offset. Price: Option 001, add $275.

005: digital programming. Provides digital control of Width, Transition Time, amplitude, Polarity, and Offset. Refer to 1900/6940A description or contact your Hewlett-Packard Field Engineer for more information.

Price: 1917A Option 005, add $2000.

Accessories

Programming kit: HP Part No. 01917-69501 provides for field installation of Option 001, $275.

Specifications, 1920A

Pulse output

Source resistance: 50 ohms ±5%.

Amplitude: 0.5 to 5 V into 50 ohms in three ranges; 1, 2, 5 sequence. 2.5:1 vernier provides continuous adjustment over each range. Output circuit cannot be damaged by shorting.

Pulse shape (measured at 5 V into 50 ohms)

Leading edge: risetime, <350 ps; preshoot, <1%, overshoot and ringing, <10% p-p; time to settle to within 3% of flat top, <5 ns; rounding <5%.

Trailing edge: falltime, <400 ps; preshoot, <1% for pulse width >5 ns; overshoot and ringing, <10% p-p; time to settle to within 3% of baseline, <5 ns except for perturbation 10-20 ns after trailing edge <±4%; rounding, <5%.

Polarity: plus or minus, selectable.

Baseline offset: plus, minus, or off; selectable, 0-2 V into 50 ohms.

Width: 0 to 10 μs in four ranges. 10:1 vernier provides continuous adjustment between ranges.

Width jitter: <20 ps or 0.1% whichever is greater.

Duty cycle: 0 to >25% (0 to 20 MHz rep. rate); 0 to 10% (>20 MHz rep rate).

Drive input

Repetition rate: 0 to 25 MHz.

Amplitude: 1 V peak min., 5 V peak max.

Maximum delay after rate input: approx 60 ns.

Input impedance: 50 ohms, dc-coupled.

General

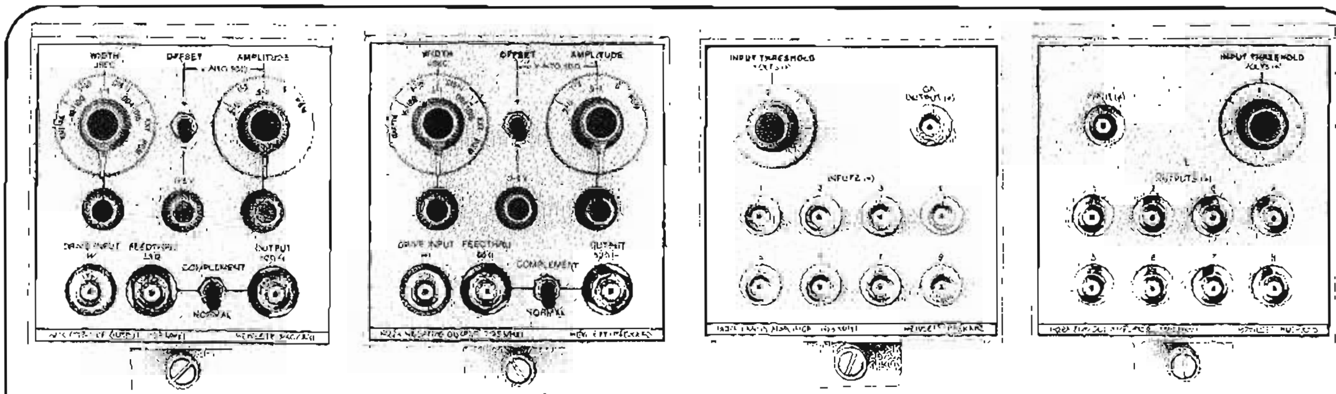
Weight: net, 4 lbs (1,8 kg); shipping, 10 lbs (4,5 kg).

Price: Model 1920A, 350 ps Rise Time Output, $1975.

Options

001: analog programming. Provides connector and circuits to control width range and vernier, offset range and vernier, and amplitude vernier.
Price: Option 001, add $150.

OUTPUT PULSE SHAPING
General purpose, fan-in and fan-out
Models 1921A, 1922A, 1927A, 1928A



1921A 1922A 1927A 1928A

Specifications, 1921A and 1922A

Output pulse

Source impedance: approx 50 ohms shunted by 9 pF. Reflection coefficient is typically <0.15 for incident pulses with rise times >1.5 ns.

Pulse amplitude: (volts into 50 ohms) 0.5 to 5 V; 2.5:1 vernier provides continuous adjustment over each range.

Polarity: 1921A, positive; 1922A, negative. Opposite pulses can be obtained from each unit by adjusting offset, amplitude and complement controls.

Duty cycle: >50% in internal; up to 100% with complement; external width mode, up to 100%.

Feedthru mode: allows output pulses to be added on a 50 ohm transmission line for bipolar applications.

Complement: selects normal pulse or its logic complement. Transition time shift: normal to complement, typically <±1 ns.

Pulse shape

Pulse top variations: <±5% for amplitudes from 1 to 5 V and <±7% for amplitudes of <1 V.

Base line offset: 0 to ±5 V into 50 ohms.

Transition times: <2 ns.

Width

Internal: ranges, 4 ns to 1 ms in 6 ranges (10:1 vernier provides continuous adjustment over each range); jitter, <25 ps +0.1% of pulse width; time intersymbol interference, width change with rep rate <1.5 ns +2% of pulse width.

External: provides pulse amplifier operation; output pulse width is determined by width of drive input. Pulse width tracking is within approx ±1 ns with input pulse width measured at 0.6 V. Time intersymbol interference: transition shift with rep rate, <1 ns.

Drive input

Repetition rate: 0 to 125 MHz.

Input impedance: 50 ohms dc-coupled.

Pulse shape: amplitude, >1.5 V; width, >3 ns; slope, >0.25 V/ns at 0.7 V in internal width, >0.15 V/ns at 0.7 V in external width (smaller slopes may cause degradation of performance).

Maximum input: ±5 V.

Propagation delay: internal width mode, approx 18 ns; external width mode, approx 15 ns; feedthru mode, approx 4 ns.

General

Weight: net, 3 lbs (1,4 kg); shipping, 6 lbs (2,7 kg).

Price: Model 1921A Positive Output, $950.
Model 1922A Negative Output, $950.

Options (order by Option number)

001: analog programming. Provides connector and circuits to control width, amplitude, complement and offset.

Price: Option 001 for 1921A or 1922A, add $150.

Specifications, 1927A and 1928A

(Except as noted, specifications apply to both fan-in and fan-out amplifiers.)

Input

Threshold: continuously variable from +0.5 V to +3 V. In 1927A, one adjustment sets all eight inputs to the same level.

Repetition rate: 0 to 125 MHz.

Amplitude: 1 V min., 4 V max.

Width: >4 ns.

Propagation delay: 1927A, <8 ns; 1928A, <10 ns.

Input impedance: 50 ohms, dc-coupled.

Output

Source impedance: unterminated current source.

Logic one: 45 mA, ±5 mA current source; >2 V into 50 ohms.

Transition times: <3 ns.

Pulse stretching: increase in pulse width is <3 ns.

1928A differential delay between output ports: <3 ns.

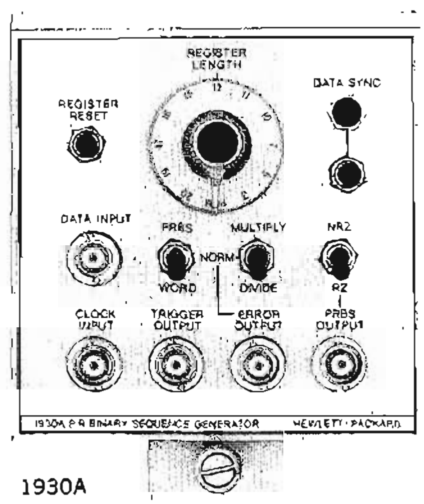
General

Weight: net, 1¼ lb (0,6 kg); shipping, 6 lb (2,7 kg).

Price:

1927A Fan-In Amplifier	$150
1928A Fan-Out Amplifier	$225

FORMATTING
Bit error detection, coding, PRBS
Model 1930A



1930A

Description, 1930A

Model 1930A is a quarter-size, formatting plug-in for the 1900 pulse system. It can generate a pseudo-random binary sequence (PRBS) in either return-to-zero (RZ) or non-return-to-zero (NRZ) formats at clock rates up to 40 MHz (typically to 50 MHz). The length of a sequence can be varied from 7 to 1 048 575 bits before being repeated. A PRBS is apparently random in that, for samples of n bits or less, it follows closely the statistical characteristics of a binomial distribution but it is deterministic and periodic.

Random signal simulation

Random signal simulation allows a device that processes digital information to be completely exercised while providing the stationary characteristics of a repetitive signal. In pattern sensitive devices, pseudo-random binary sequences provide a fast, easy and complete method of generating all possible combinations of up to 20 bits for detecting worst case patterns. Also, in an n cell device, a random sequence can be generated that is 2^n-1 bits long and contains all possible combinations of n bits except the all zeros combination. In 1930A, n can be between 3 and 20, thus it is possible to select the sequence length to avoid "beating" with other signals in the device being exercised.

Bit error detection

One of the main reasons for testing digital processing equipment is to determine how accurately the transmitted signal is received and to find the effect of noise in the transmission system. A measure of the quality of a digital system is Bit Error Rate (BER).

Bit error detection in digital transmission systems is simplified by the ability of 1930A to synchronize rapidly to a data stream (either words or pseudo-random sequences) and compare the incoming data bit by bit with a stored replica. For example: one 1930A generates a signal that is transmitted over a digital communication link while a second 1930A synchronizes to the incoming signal from the link. Each time the received signal differs from the stored replica an error pulse is produced at the error output. Error pulses can be counted to provide the bit error rate. This technique is not restricted to transmission systems, it is equally applicable when testing mass-storage memory devices.

Coding

Coding in digital applications is accomplished by dividing the incoming data stream by the characteristic equation of the generator. The pseudo-random binary sequence completely scrambles the original data in both time and frequency domains. Eleven different scrambling patterns can be selected with a front panel register length switch, and feedback tapes inside the plug-in allow over 73,000 different pseudo-random patterns. Scrambling patterns may also be set by remote, electronic program signals through the rear panel of an Option 001 mainframe. To decode the information, another 1930A set to the same sequence multiplies the scrambled signal by the same equation to regain the original data.

Specifications, 1930A

Clock input

Repetition rate: 0 to 40 MHz (typically to 50 MHz in most sequences).
Input R: 50 ohms, dc-coupled.
Amplitude: +1 V min.
Width: >4 ns and <15 ns.
Propagation delay: 40 ns max. (clock input to transition of output data).
Maximum input: ±5 V.

Data input

Repetition rate: 0 to 40 MHz (typically to 50 MHz).
Input R: 50Ω, dc-coupled.
Amplitude
One level: +1 V min.
Zero level: 0 V.
Maximum input: ±5 V.

Trigger output

Amplitude: 1 V (open circuit).
Width: approx 1 clock period.
Source R: 50 ohms.

Error output

Amplitude: 45 ±5 mA current source or >2 V into 50 ohms.
Width: >10 ns, <50% of period in RZ mode.
Source R: unterminated current source.
Self generated error rate: <1 x 10^{-12}.

PRBS output

Amplitude: 45 mA ±5 mA or >2 V into 50 ohms.
Rise and fall times: <4 ns.
Width: typically >7 ns and <14 ns.
Source R: unterminated current source.

Programming inputs
(Requires Option 001 1900A or 1901A Mainframes)

False: contact closure to <0.6 V.
True: open or >3.0 V.
Response: <300 ns.
Threshold: approx 2.2 V or 5.5 k ohms.

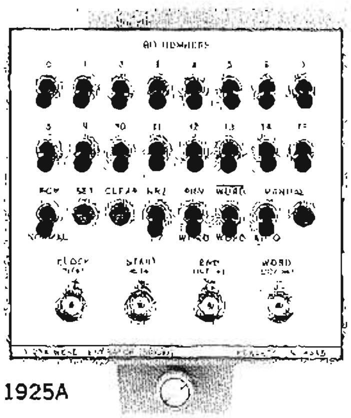
General

Weight: net, 2¼ lb (1,02 kg); shipping, 4½ lb (2,04 kg).
Price: Model 1930A, PR Binary Sequence Generator, $1200.
Options
005: digital programming. Enables control by a 6940A Multiprogrammer. For more information see 1900/6940A description or contact your Hewlett-Packard field engineer. Price: Option 005, add $300.

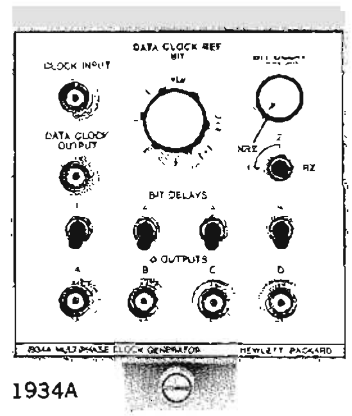
DIGITAL FORMATTING

Word and multiphase clock generators

Models 1925A, 1934A



1925A



1934A

- 0 to 50 MHz Clock
- 2 to 16 Bit Words
- RZ/NRZ Formats
- Word/Word Complement

- Selectable Phase Pattern
- 2 Phase, 25 MHz
- 4 Phase, 12.5 MHz
- RZ/NRZ Formats

Specifications, 1925A

Clock input

Repetition rate: 0 to 50 MHz (15 to 35°C), 0 to 45 MHz (0 to 50°C).
Input impedance: 50 ohms, dc-coupled.
Amplitude: +1 V min, +5 V max.
Width: >4 ns, <18 ns at +0.6 V.
Propagation delay: 35 ns max., leading edge of transition of output data.
Transition time jitter: (between clock or END and WORD-OUT) 100 ps.

Start input

Period: >(word length plus 30 ns).
Input impedance: 50 ohms, dc-coupled.
Amplitude: +1 V min, +5 V max.
Width: >5 ns.

Programming inputs (requires 1900A Option 001 or 1901A Option 001 mainframe).

True: contact closure, saturated DTL, or voltage source (TTL) <+0.2 V.
False: open, off DTL, or voltage source (TTL) >2.5 V, <4.0 V.
Noise immunity: >0.7 V p-p. When true <0.2 V, when false >3.5 V.
Noise bandwidth: <15 MHz.

Word and End output

True: 45 ±5 mA current source or >1 V into 25 ohms.
False: <1 mA.
Risetime and falltime: <4 ns.
Perturbations: <15%.
Source impedance: unterminated current source.
Word length: 2 to 16 bits, set by internal switches.
Word content: set by front panel switches or programmed.

General

Weight: net, 2¼ lb (1,02 kg); shipping, 4½ lb (2,04 kg).
Price: Model 1925A, Word Generator $850.

Options

005: digital programming. Enables digital control from a 6940A Multiprogrammer. For more information, see 1900/6940A description or contact your Hewlett-Packard Field Engineer.

Price: Option 005, add $300.

Specifications, 1934A

Clock input

Repetition rate: dc to >50 MHz.
Width: >4 ns and <½ clock period.
Input R: 50 ohms, dc-coupled.
Amplitude: ≥+1 V or <+3 V.
Maximum input: ±5 V.

Data clock output

Repetition rate: two phase, ½ input rate; four phase, ¼ input rate.
Width: <15 ns.
Transition times: <4 ns.
Source impedance: emitter follower voltage source.
Amplitude: >2 V into 50 ohms.
Position with respect to matrix bit: >15 ns advance.

Phase outputs

Amplitude: 45 mA ±5 mA or >2 V into 50 ohms.
Repetition rate: two phase, dc to >25 MHz; four phase, dc to >12.5 MHz.
Width: NRZ, one input clock period; RZ, <10 ns.
Source impedance: unterminated current source.
Transition time: <4 ns.

Bit delay

Range 1: 7 to 35 ns.
Range 2: 35 to 500 ns.
Vernier: provides variable delay between trailing edge of preceding bit and leading edge of selected bit and must not exceed ½ input clock period delay time.

Programming inputs (requires 1900A Option 001 or 1901A Option 001 mainframe).

Functions

False: contact closure to <0.6 V.
True: open or >3 V.
Settling time: <300 ns.
Threshold: approx 2.1 V or 5700 ohms.

Vernier

Sustaining voltage: −4.7 V.
Current: −0.7 mA to −10 mA.

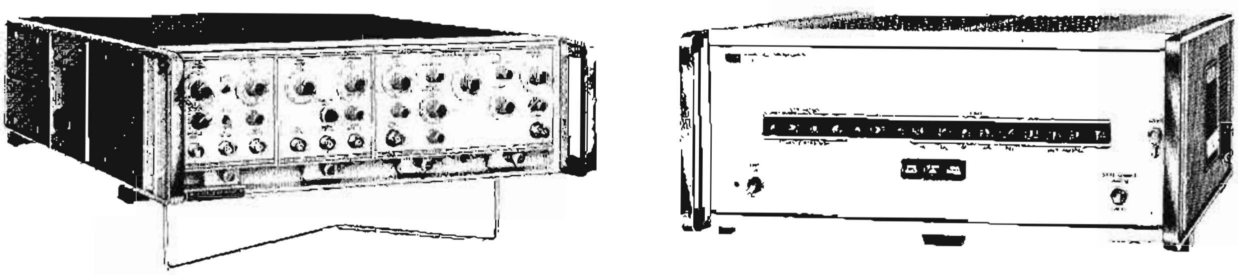
General

Weight: net, 2¼ lbs (1,02 kg); shipping, 4½ lbs (2,04 kg).
Price: Model 1934A, Multiphase Clock Generator $775

PROGRAMMING THE 1900

Complete pluse generator control

1900/6940A



1900 6940

Introduction

The capability of a pulse generator to be programmed, enables it to be incorporated in automatic or semi-automatic test systems. This added flexibility is invaluable for applications that require several different but repeatable pulse waveforms. Hewlett-Packard offers this capability in a number of their pulse generators, particularly in the 1900 series.

Analog programming

Analog programming is particularly suitable for simple applications where only partial remote control is needed or when only a few pulse waveforms are required repeatedly. Available in the 1900 series are eight plug-ins which feature analog programming as an option. They are:

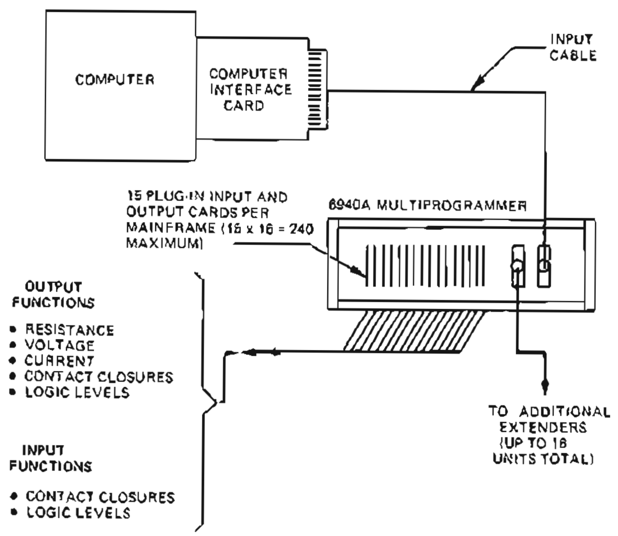
1905A 001 1906A 001 1908A 001 1909A 001	1915A 001 1920A 001 1921A 001 1922A 001	Programming of these modules requires an option 001 1900A or 1901A mainframe.

Also, in the range of dedicated pulse generators, Model 8003A is analog programmable when ordered with Option 001. Programming is by contact closure for ranges and by resistor or analog current for vernier functions.

Digital programming

For flexible control of a pulse generator, digital programming is the answer and Hewlett-Packard's contribution is the 1900/6940A programmable pulse generator.

The plug-in 1900 system and the 6940A Multiprogrammer allows reliable and efficient control of a large number of functions by a mini-computer, using only a single 16 bit I/O slot. Up to fifteen 6941A Extenders may be added to provide control of up to 240 separate functions still using only one computer I/O slot.



Available in the 1900 series are six plug-ins which feature digital programming as an option. They are:

1905A 005 1908A 005 1915A 005	1917A 005 1925A 005 1930A 005	Programming of these modules requires an Option 001 1900A or 1901A mainframe.

Only the functions with parameters to be varied need be programmable. For the others, standard plug-ins may be used or part of the programming hardware can be omitted. For example; if only the width of an output stage and not offset, amplitude, etc. is to be programmed, then the cards in the 6940/6941A which would be required to control these non-varying parameters can be omitted.

The 1900/6940A works with any digital computer, however, for Hewlett-Packard digital computers, software in FORTRAN and BASIC is available.

PROGRAMMING THE 1900
Complete pulse generator control
1900/6940A, Specifications

Specifications, 1900/6940A

Pulse parameter specifications are contained in the individual specifications for each plug-in. The following specifications apply to programming accuracies for the 1905A, 1908A, 1915A, 1917A, 1925A and 1930A.

Model 1905A Rate Generator
Programmable functions

Period: 25 Hz to 25 MHz in 6 ranges.
Accuracy: ±5% of digital input or ±10 ns, whichever is greater.
Resolution: 360 points in each range.

Mode: + Ext, − Ext, Internal.
Response time: <30 ns plus one period.

General

Multiprogrammer slots required: 1 slot for data distribution and power.

Equipment supplied: 1 output card and interconnecting cables.

Model 1908A Delay Generator
Programmable functions

Mode: delay, advance, double pulse.

Delay interval: 15 ns to 10 ms in 6 ranges.
Accuracy: ±5% of digital input or ±10 ns, which ever is greater.
Resolution: 900 points in each range.
Response time: <30 μs plus one period.
Duty cycle: 50% max.

Temperature range: 10°C to 40°C. From 0°C to 55°C, specifications are the same except for Accuracy, which is ±15% of digital input or ±10 ns, which ever is greater.

General

Multiprogrammer slots required: 1 slot for data distribution and power.

Equipment supplied: 1 output card and interconnecting cables.

Model 1915A Variable Transition Time Output
Programmable parameters

Width: 15 ns to 40 ns in 7 ranges.
Accuracy: ±10% of digital input or ±10 ns, which ever is greater.
Resolution: 360 points in each range.
Response time: <30 μs plus one period.
Duty cycle: 50% max.

Transition time: 7 ns to 100 μs in 5 ranges.
Accuracy: ±15% of digital input or 10 ns, which ever is greater.
Resolution: 450 points in each range.
Response time: <30 μs plus one period.

Amplitude: 0.05 A to 1.0 A (1.25 V to 25 V into 25 ohms) in 4 ranges.
Polarity: positive or negative.
Accuracy: digital input ±5% of max. vernier on each range.
Resolution: 300 points in each range.
Response time: <50 ms for 50 V pulses from high Z source into 50 ohm load. <15 ms for 25 V pulses from 50 ohm source into 50 ohm load. Typically >500 μs for duty cycle >0.2%.

Offset: 0 to 60 mA in 1 range (0 to 1.5 V into 25 ohms).
Polarity: positive or negative.
Accuracy: ±2 mA of digital input (±50 mV into 25 ohms).
Resolution: 150 points.
Response time: <250 μs.

Temperature range: 10°C to 40°C. From 0°C to 55°C, specifications are the same except for the following: Offset Accuracy, ±15% or 60 mV, which ever is greater; Transition Time Accuracy, ±20% or ±10 ns, which ever is greater; Width Accuracy, ±15% or ±10 ns, which ever is greater; Amplitude Accuracy, ±15% or ±50 mV, whichever is greater.

General

Multiprogrammer slots required: 5 slots for data distribution and power.

Equipment supplied: 5 output cards and interconnecting cables.

1917A Variable Transition Time Output
Programmable parameters

Width: 15 ns to 40 ms in 7 ranges.
Accuracy: ±5% of digital input or ±10 ns, which ever is greater.
Resolution: 360 points in each range.
Response time: <30 μs plus one period.
Duty cycle: 50% max.

Transition time: 7 ns to 100 μs in 5 ranges.
Accuracy: ±15% of digital input or ±5 ns, which ever is greater for all amplitudes between 2 and 10 volts.
Resolution: 450 points on each range.
Response time: <30 μs plus one period.

Amplitude: 0.2 V to 10 V in 5 ranges.
Polarity: positive or negative.
Accuracy: ±5% of digital input or ±50 mV, which ever is greater.
Resolution: 300 points in each range.
Response time: <30 μs plus one period.

Offset: 0 to 2.5 V in one range.
Polarity: positive or negative.
Accuracy: ±7% or ±70 mV of digital input, which ever is greater.
Resolution: 250 points.
Response time: <80 ms.

Temperature range: 10°C to 40°C. From 0°C to 55°C, specifications are the same except for the following: Offset Accuracy, ±15% or 60 mV, which ever is greater; Width Accuracy, ±15% or ±10 ns, which ever is greater; Transition Time Accuracy, ±20% or ±10 ns, which ever is greater; Amplitude Accuracy, ±15% or ±50 mV, which ever is greater.

General

Multiprogrammer slots required: 5 slots for data distribution and power.

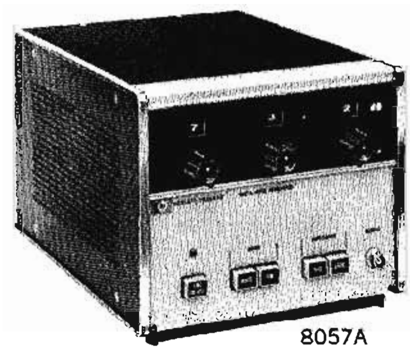
Equipment supplied: 5 output cards and interconnecting cables.

Model 1925A Word Generator
(Specifications identical to standard version.)

Model 1930A PR Binary Sequence Generator
(Specifications identical to standard version.)

Model 14090 kit is required to adapt the Model 6940A to the Model 1900/01.

PULSE AND NOISE SOURCES
Precise noise, high power and square wave
Models 8057A, 211B, 221A, 214A

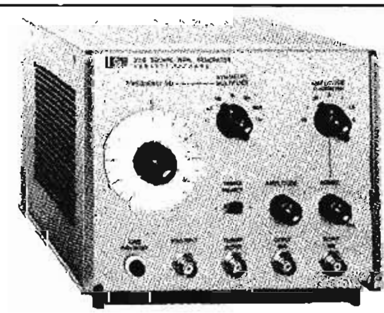


8057A

Model 8057A Precision Noise Generator

The Hewlett-Packard 8057A Precision Noise Generator is an audio frequency noise generator which produces pseudo-random signals available at Gaussian distribution and binary outputs. These signals are repeated noise patterns of known content and duration. Both white and pink noise with an equal rms value can be selected by pushbuttons as well as output impedance (50 ohm or 600 ohm). By producing a defined rms value, the high stability of the output level allows the use of a directly calibrated attenuator with 0.1 dB resolution. This makes the 8057A a highly accurate noise source. The frequency spectrum goes from dc to 26 kHz.

Price: Model 8057A, Precision Noise Generator, $945.



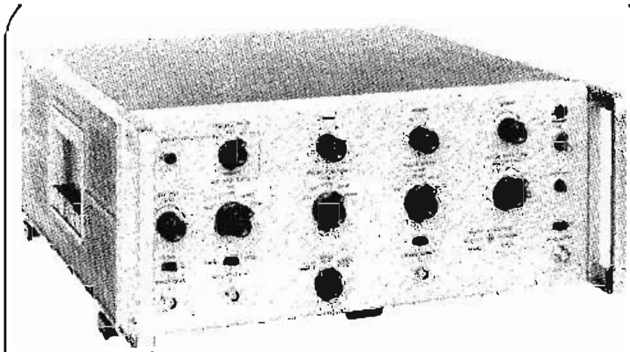
Description, 211B and 221A

The Hewlett-Packard Models 211B and 221A are compact, general purpose square wave generators with frequency coverage from 1 Hz to 10 MHz. The 211B features two simultaneous outputs, one from a 50 ohm source and the other from a 600 ohm source, with 180° phase difference between the two. A symmetry control permits variation of the "on" time from 25% to 75% of the period.

Model 221A delivers square waves with amplitudes variable from 0 to 5 V (into 50 ohms) from a single output with 50 ohm source impedance. Frequency programming capability is standard as is output gating. Also, Model 221A may be used as a voltage controlled oscillator (VCO) by applying a dc voltage to a rear panel connector. This enables the frequency to be swept over the full 10:1 range selected.

Price: Model 211B Square Wave Generator, $490; Model 221A Square Wave Generator, $240.

For complete specifications contact your Hewlett-Packard field engineer.



214A

Description, 214A

The high 200 watts of pulse power (2 amp peak, ±100 volts into 50 ohms) and fast risetime of 15 ns are particularly suited for testing current-driven devices, such as magnetic cores, as well as high-power modulators. To minimize errors caused by reflections when operating into unmatched loads, source impedance is 50 ohms. At lower output levels, the risetime is less than 13 ns (typically less than 10 ns). Carefully controlled pulse shape, pulse rate and width, and minimum pulse jitter ensure accurate and dependable test results. All characteristics of the pulse waveform, including overshoot, preshoot, pulse droop and pulse top variations, are completely specified, and pulse irregularities are kept to a minimum.

Specifications, 214A

Output pulse

Source resistance: 50 ohms on 50 V and lower ranges; approx 1500 ohms on the 100 V range.

Transition times: <13 ns on 20 V and lower ranges and the −50 V range, <15 ns on the +50 V range; typically <10 ns with the vernier set for maximum attenuation and typically 15 ns on the 100 V range.

Pulse amplitude: 100 V into 50 ohms. Attenuator provides 0.2 to 100 V in 1, 2, 5, 10 sequence (9 ranges); vernier reduces output of 0.2 V setting to 80 mV and provides continuous adjustment within ranges.

Polarity: positive or negative.

Overshoot: <5%, both leading and trailing edges (measured on a 50 MHz oscilloscope).

Pulse top variation: <5%.

Droop: <6%.

Preshoot: <2%.

Pulse widths: 50 ns to 10 ms in 5 decade ranges; continuously adjustable vernier.

Width jitter: <0.05% of pulse width +1 ns.

Maximum duty cycle: 10% on 100 V and 50 V ranges; 25% on 20 V range; 50% on 10 V and lower ranges.

Internal repetition rate: 10 Hz to 1 MHz (5 ranges), continuously adjustable vernier.

General

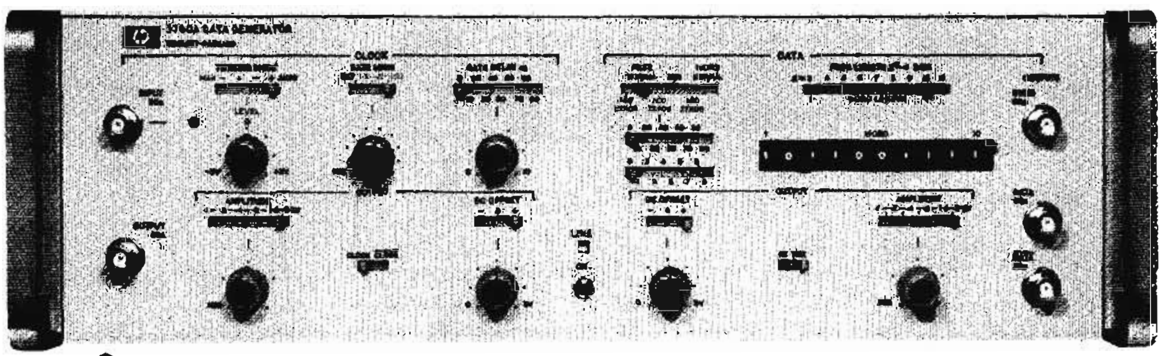
Power: 115 or 230 V ±10%, 48 to 66 Hz, approx 325 VA.

Dimensions: 16¾" wide, 7¼" high, 18⅜" deep (425 x 184 x 467 mm).

Weight: net, 35 lbs (16,8 kg); shipping, 41 lbs (19,7 kg).

Price: Model 214A Pulse Generator, $1095.

DATA GENERATOR
PRBS and WORD generation up to 150Mb/s
Model 3760A



NEW

3760A

The 3760A Data Generator is a fast, versatile PRBS and WORD generator intended for both factory and field use, with many features which make it especially attractive for applications in high frequency digital communications.

The clock frequency, in the range 1.5 to 150 MHz can be derived from an internal clock generator (optional) or the unit can be manually or automatically triggered from an external clock. A clock output, variable in amplitude from 0.1 to 3.2 V pk-pk with a rise time of better than 1 ns, is also provided.

The pseudo-random binary sequence, PRBS, is variable in length from $2^3 - 1$ to $2^{10} - 1$ bits, with an additional long sequence of $2^{15} - 1$ bits. A sync pulse occurs once per sequence and can be used to initiate a block of 1 to 99 zeros. This block is inserted into the data stream to facilitate the clock extraction tests used in some PCM systems. As the 3760A Data Generator is often used in conjunction with the 3761A Error Detector, a deliberate error can be inserted once per 2000 PRBS sequences to check the accuracy of the 3760A/61A system.

The length of the binary word is variable from 3 to 10 bits and its content is selected on the front panel. A sync pulse occurs once per sequence and again it can be used to initiate a block of zeros which is inserted between words. Alternatively, the preprogrammed maximum change sequence, 1010 can be selected.

The data output which can be PRBS, WORD or the fixed maximum change sequence, 1010, is available simultaneously in normal and complemented form. As with the clock, these outputs are calibrated from 0.1 to 3.2 V pk-pk in amplitude and 0 to ±3 V dc in offset with rise times of better than 1 ns. Either RZ or NRZ formats may be selected and the data output can be delayed by up to 100 ns with respect to the clock.

Specifications

Modes of operation

PRBS normal: Generates a repetitive $2^n - 1$ bit, maximal length, PRBS; where n = 3 to 10 and 15.

PRBS zero add: Addition of a block of 1 to 99 zeros into PRBS normal.

PRBS error: Error introduced once per 2000 sequences.

1010: Generates a preset repetitive word, content 1010.

Word normal: Generates a continuous 3 to 10 bit word.

Word zero add: Addition of a block of 1 to 99 zeros into word normal, occurring between words.

Clock input

Rate: 1.5 to 150 MHz.

Impedance: 50Ω ±5% dc coupled.

Trigger: +ve or −ve slope.

Manual: Level range −3 to +3 V.

Auto: Input pulse mark: space ratio range 10:1 to 1:10.

Sensitivity: Better than 500 mV.

Pulse width: 3 ns minimum.

Clock output

Outputs: CLOCK or $\overline{\text{CLOCK}}$.

Impedance: Source impedance 50Ω ±5%.

Amplitude: Continuously variable in 5 ranges from 0.1 to 3.2 V into 50Ω, symmetrical about offset level.

Rise/fall time: <1 ns (10% to 90% level).

DC offset: Variable, 0 to ±3 V.

Data output

Outputs: DATA and $\overline{\text{DATA}}$ simultaneously.

Format: RZ or NRZ.

Delay: Data (and Sync) delayed with respect to Clock continuously in 10 ranges from 0 to 100 ns.

Other specifications as for clock output.

Sync output

Rate: Once per PRBS or WORD cycle.

Amplitude: +1 V into 50Ω.

Options

001: 75Ω CLOCK and DATA input/output impedances.

002: Internal variable frequency clock, 1.5 to 150 MHz.

003: Options 001 and 002 combined.

General

Power: 90 to 125 V or 200 to 250 V, 40 to 400 Hz, consumption 90 W.

Weight: 30 lbs (13.5 kg).

Dimensions: 16¾ in wide x 5½ in high x 18¾ in deep. (425 mm x 140 mm x 467 mm).

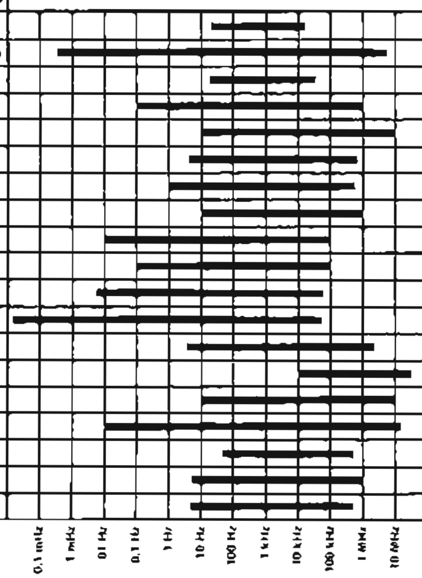
GENERAL INFORMATION

Oscillators, Function Generators

Signal sources have been described by various names—oscillators, test oscillators, audio signal generators, function generators, etc. Different names are applied, depending on the design and intended use of the source. In recently developed sources, the name "test oscillator" has been used to describe an oscillator having a calibrated attenuator and output monitor. The term "signal generator" is reserved for an oscillator with modulation capability.

A function generator is a signal generator that delivers a choice of different waveforms with frequencies adjustable over a wide range. Function generators produce sine, triangle, square wave, sawtooth waves, and pulses with a provision to sweep. Hewlett-Packard's function generators extend from a low frequency of 0.00005 Hz (HP 203A Option 002) up to a high frequency of 5 MHz (HP 3310A).

FUNCTIONS: sine	square	triangle	pulse	ramp	FREQUENCY RANGE	POWER OUTPUT	INST	PAGE
●						3 W	201C	317
●	●	●	●	●		1.1W	3310A/B	324
●						1 W	200AB	317
●	●	●	●			200 mW	3311A	325
●						200 mW	651B/652A 654A	323
●						160 mW	200CD	317
●						160 mW	202C	317
●						160 mW	4204A	319
●	●	●				100 mW	3300A	321
●	●	●				100 mW	3300A 3306A	322
●	●					40 mW	203A*	320
●	●					40 mW	203A* (Opt. 002)	320
●	●					40 mW	209A	318
●						20 mW	675A	413
●						20 mW	653A	432
●						20 mW	3320A/B	328
●						10 mW	236A	430
●						10 mW	204C	318
●						10 mW	208A	319



* Four outputs two variable phase

Table 1. Functions, frequency range and power output of Hewlett-Packard oscillators, and function generators.

Basic requirements

In selecting an oscillator or function generator, the user will be most interested in its frequency coverage. The question to be answered here is, "Will the instrument supply both the lowest and highest frequencies of interest for anticipated tests?" As shown in Table 1, Hewlett-Packard manufactures a broad range of oscillators and function generators covering the frequency spectrum from 0.00005 Hz to 32 MHz.

The user's next concern will be with the available output power or voltage. Some tests require large amounts of power, while others merely require sufficient voltage output. For almost any application, there is a Hewlett-Packard oscillator capable of delivering the desired voltage output into a high-impedance load or of supplying the desired power into lower impedance loads.

Besides frequency range and power output, the user will be interested in the instrument stability, its dial resolution, and the amount of harmonic distortion, hum and noise in the output signal, and functions available. See Table 1 for a comparison of Hewlett-Packard oscillators and function generators.

Frequency stability

The frequency stability of the oscillator determines the ability of the instrument to maintain a selected frequency over a period of time. Component aging, power-supply variations and temperature changes all affect stability. Carefully chosen components, such as precision resistors and variable capacitors in the frequency-determining networks, contribute to long-term stability.

Amplitude stability

Amplitude stability is important in certain oscillator applications. Amplitude stability is inherent in the Hewlett-Packard RC oscillator circuit because of the large negative feedback factor and the amplitude stabilizing techniques. The "frequency response," or amplitude variation as the frequency is changed, is of special interest when the oscillator is used for response measurements throughout a wide range of frequencies.

Distortion

Distortion in the oscillator's output signal is an inverse measure of the purity of the oscillator's waveform. Distortion is undesirable in that a harmonic of the test signal may feed through the circuits under test, generating a false indication at the output. If the oscillator is used for distortion measurements, the amount of distortion that it contributes to the measurements should be far less than that contributed by the circuits under test.

Hum and noise

Hum and noise can be introduced at a variety of points in oscillator circuits; but when the circuit operates at a relatively high level, the amount of hum and noise introduced into the device under test is usually negligible. Hum and noise introduced by a power amplifier usually remain constant as the output signal amplitude is diminished. Hence, even though the hum and noise power may be quite small compared to the rated output, these spurious signals sometimes become a significant portion of low-level output signals. To overcome such a limitation, many Hewlett-Packard oscillators have their amplitude control on the output side of the power amplifier so that hum and noise are reduced proportionally with the signal when low-level signals are desired for test purposes.

Function generators

The function generator has emerged as a versatile multiwaveform signal source capable of very wide frequency coverage. The function generator has become an indispensable general purpose signal source for production testing, instrument repair, and the electronics laboratory. The diverse fields of applications in which the function generator is being used include medical research, education, chemical, communications, geo-

GENERAL INFORMATION

physics, industrial control, military, and aerospace.

Most function generators are designed around the block diagram shown in Figure 1.

The basis of this circuit is the generation of a triangle waveform through a feedback network. The upper current source delivers 2I to the integrator and the lower current source takes away —I. This, with the upper current source "on" the integrator, charges linearly with a current I. The output of the integrator

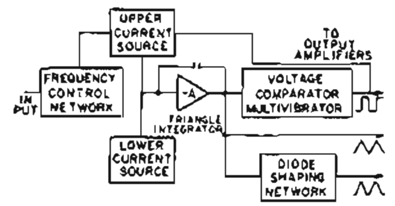


Figure 1. Block diagram, typical function generator.

is sensed by a voltage comparator. When the proper level is reached, the comparator is triggered which in turn "disconnects" the upper current source. With the upper current source disconnected, the integrator discharges linearly at a —I rate due to the lower current source. When the proper discharge voltage is reached, the comparator again triggers turning "on" the upper current source; thus, completing the cycle. The resulting triangular waveform is varied in frequency by changing the charge current I. To obtain a sine wave, the triangular waveform is processed by a diode shaping network. The square wave is already available at the output of the voltage comparator. By varying the current ratio between the two current sources, ramp and pulse waveforms may be generated.

3310A/B

The 3310A/B utilizes this basic circuit with many refinements resulting in a versatile seven function instrument covering a frequency range from 0.0005 Hz to 5 MHz. The 3310B has the additional capability of tone burst with variable start/stop phase.

3311A (New)

For the user with general requirements and a tight budget, the 3311A is an ideal choice. This instrument generates sine, square, triangle, and pulse waveforms over a 0.1 Hz to 1 MHz frequency range. The small size, cast aluminum case, and output protection make it a rugged performer.

3300A

The 3300A Series offers the user a broad selection of functional capability through the use of plug-ins. The 3300A, in combination with the 3302A, offers triggered and phase lock of the mainframe. The phase between locking signal and the mainframe output is continuously variable through a front panel control.

The combination of the 3300A mainframe with the 3304A Sweep/Offset Plug-in provides internal sweeping up to a decade of frequency, and complete offset capability of all mainframe output functions.

If a log sweeper is called for in your audio testing, the 3300A combined with the 3305A Plug-in is the answer. This combination will sweep from 0.1 Hz to 100 kHz (6 decades) in one continuous sweep. Narrower sweeps can also be made through independent start/stop adjustments.

209A

A modification to the Wien bridge oscillator is the 209A Sine-Square Wave Oscillator. Stable, accurate signals, which can be synchronized with an external source, are instantly available over a frequency range of 4 Hz to 2 MHz. The amplitude of the sine and square wave outputs are separately adjustable and are available simultaneously. Distortion and flatness can be improved at low frequencies by a low distortion modes switch.

203A

Another Hewlett-Packard generator is the 203A Variable Phase Function Generator. This instrument has a sine wave and square wave output with a second channel that can be phase-shifted continuously through a full 360° range.

Although this function generator is intended primarily for low-frequency work, it has a frequency range extending from 60 kHz down to 0.005 Hz or, with options, down to as low as 0.00005 Hz (five hours for one cycle). All four output signals are supplied simultaneously and all have individual 40 dB attenuators.

For a stable, low-distortion sine wave source, the 203A is ideal, for it has less than 0.06% combined harmonic distortion, hum and noise at full output.

Selecting An Osc./Function Gen.

In selecting an oscillator or function generator, the user is faced with a broad spectrum of available instruments. To narrow this spectrum, the following guidelines may be used:

1. Define current requirements and probable future requirements in terms of frequency range, power output, functional capability desired,* sine wave harmonic distortion, frequency stability, and output flatness vs. frequency.

* Functions of interest are: multiple output, output level monitor, calibrated attenuator, sine wave, square wave, pulse, ramp, dc offset, triggered output, pulse, phase lock, ramp, dc offset, and modulation capability. Another feature which may be of interest is internal sweep. Most function generators may be swept externally, some have internal sweep as well. The sweep may be linear for narrow-band testing or log for multidecade sweeps.

2. If your application is general purpose in nature with no stringent requirements, such as .01% harmonic distortion, consider the function generator. This class of instruments may be used as a sine wave source, square wave test source, pulse generator, low frequency ramp for x-y recording, etc. If, however, any of the intended applications have specific requirements, the function generator will, in most cases, not have sufficiently tight specs to satisfy these requirements. In this case, the user must look to dedicated instrumentation.
3. In general, test oscillators or oscillators will be your choice when large voltage output or low harmonic distortion are requirements.
4. If frequency stability and accuracy are paramount requirements, then synthesizers should be considered. (See page 326.)
5. Specialized output impedances other than 50 or 600 ohm single-ended, will require specialized instruments such as the 654A.
6. If maximum versatility per dollar is the prime consideration, then function generators are your best choice.
7. In the sub-Hertz frequency range, the function generators are top performers.
8. For digital frequency selection, the 4204A or the frequency synthesizers should be considered.

VOLTMETER CALIBRATOR
DC, rms and p-p volts; flatness 10 Hz-10MHz
Model 738BR Option E02 (738BR & 652A)

Description

The 738BR Option E02 Voltmeter Calibration system combines the 652A Test Oscillator and the 738BR Voltmeter Calibrator. These instruments calibrate high impedance voltmeters and oscilloscopes for both frequency response and voltage accuracy. The system calibrates for ac* and dc voltage levels from 300 μV to 300 V in precise preselected steps and calibrates for frequency response from 10 Hz to 10 MHz.

Specifications

738BR Opt E02 Voltmeter Calibration System

738BR

Voltage range: 300 μV to 300 V, dc or ac (rms and p-p, 400 Hz).

Levels: calibration voltage 300 μV to 300 V in steps of 1, 3, 1.5 and 5; tracking voltages 0.1 to 1 V in 0.1 V steps and 0.05 to 0.5 V in 0.05 V steps.

Accuracy: 300 V working voltage into attenuator, accurate within 0.1% dc and 0.2% ac, after a 30-minute warmup.

Attenuator accuracy: within ±0.1% or ±2.5 μV, whichever is larger, open circuit.

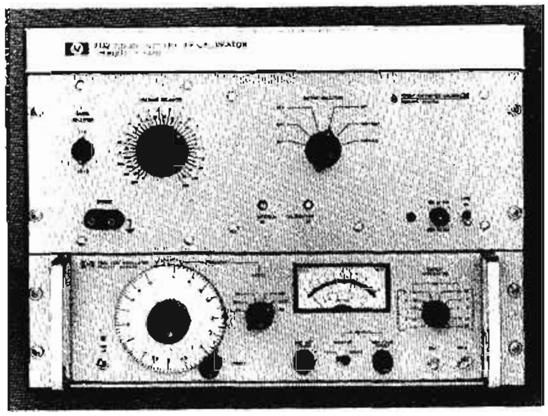
Long-term stability: drift per week: <0.1% dc, <0.2% ac.

Power: 115 or (230 V must be specified) ±10% 50 to 60 Hz, 275 VA max.

Dimensions: 19" wide, 7" high, 15¾" deep behind panel (483 x 178 x 400 mm).

Weight: net, 38 lbs (17 kg); shipping, 50 lbs (22,6 kg).

Price: HP 738BR (rack mount), $1100.



E02-738BR

652A: Specifications are listed on page 323 of this catalog.

General (738BR Opt. E02)

Dimensions: 20½" wide, 15⅝" high, 18½" deep (521 x 397 x 470 mm).

Weight: net, 75 lbs (33,8 kg); shipping, 110 lbs (49,8 kg).

Accessories furnished: cable HP Part Number 739A-16A, BNC to shielded 50Ω terminated dual banana plug.

Price: HP 738BR Option E02, $2360.

*Refers to 400 Hz only; see data sheet.

THERMAL CONVERTERS
Ideal to check response of ac voltmeter calibrators
Models 11049A, 11050A, 11051A

Description

Hewlett-Packard Thermal Converters are true rms detectors, yielding a dc output voltage proportional to the temperature rise resulting from the input power. The Models 11049A, 11050A and 11051A offer an exceptionally flat response and nearly constant impedance over a wide frequency range; a characteristic which makes these devices ideal to check the response of precision ac voltmeter calibrator (such as the HP Model 738BR Option E02) and to check the response of ac voltmeters.

Specifications

Maximum input voltage:

11049A: 3 V rms; 11050A: 1 V rms; 11051A: 0.45 V rms.

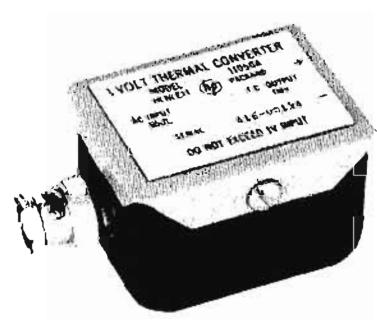
Input impedance: 50Ω ±0.15Ω to 10 MHz.

Output voltage for maximum input voltage: 7.5 mV dc (nominal).

Output impedance: <10Ω.

Calibration accuracy

Frequency range	In reference to std.	Standard measurement uncertainty
20 Hz to 20 kHz	within ±0.01%	±0.02%
20 kHz to 50 kHz	within ±0.01%	±0.03%
50 kHz to 1 MHz	within ±0.01%	±0.06%
5 Hz to 20 Hz and 1 MHz to 10 MHz	within ±0.05%	±0.12%
10 MHz to 30 MHz		±0.25%
30 MHz to 60 MHz		±0.50%
60 MHz to 100 MHz		+1.50%



11050A

Dimensions: 3" wide, 1¾" high, 1½" deep (7,6 x 4,4 x 3,8 cm).

Weight: net 2.2 oz (62 g); shipping 1 lb (450 g).

Price:

HP Model 11049A*, $125; HP Model 11050A*, $125; HP Model 11051A*, $125.

Option 001*: calibration to 60 MHz, add $30.

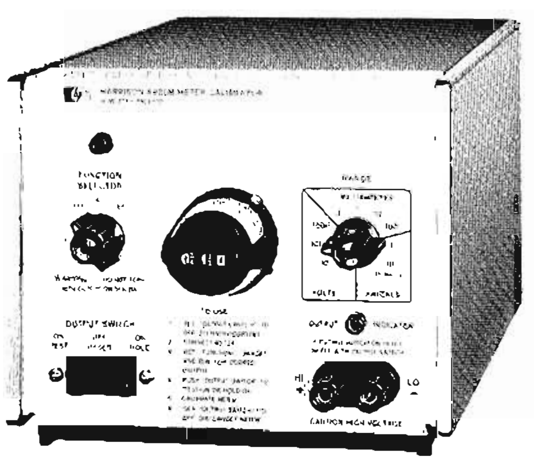
Option 002*: calibration to 100 MHz, add $50.

*Includes individual calibration report with statement of uncertainty, traceable to NBS. Options include individual correctional data sheet attached to calibration report.

AC/DC METER CALIBRATOR

Four calibrators in one case

Model 6920B



6920B

Can be used to check:

1. DC Voltmeters up to 1000 volts
2. Average reading AC Voltmeters up to 1000 volts
3. DC Ammeters up to 5 amps
4. Average reading AC Ammeters up to 5 amps

Description

Model 6920B is a versatile ac/dc meter calibrator, capable of both constant voltage and constant current output. Its absolute accuracy makes it suitable for laboratory or production testing of panel meters, multimeters, and other meters having accuracy of the order of 1.0% or higher. This calibrator has been designed for convenience, and combines in one instrument all the outputs needed to test the more commonly used meters. Model 6920B has been packaged in an HP cabinet module suitable for bench or rack use.

Output switch

An output switch selects the safest mode of operation for the particular type of meter being tested. A "lock" position leaves the testing parameters in operation to free both hands for attaching and disconnecting successive meters. A spring-loaded "test" position facilitates testing meters with several full-scale values and reduces the danger of burn-out.

AC Output waveshape

When the function switch is set on "AC", the output waveshape is sinusoidal (to a first approximation) and has the same frequency as the input line power applied to the instrument (except when an external ac reference is used). The feedback loop, which controls and regulates this ac, is actually monitoring the average value of the ac output, although the front panel controls are calibrated in terms of rms. Thus, this calibrator is suitable for use with average reading ac voltmeters scaled in rms. In addition, the calibrator can be used with true rms meters, provided allowance is made for the total output distortions. This distortion is approximately equal to the line input waveshape distortion (or distortion of the external ac reference) plus 3%.

Specifications

Input: 115 V ac ±10%, single phase, 58-62 Hz, 0.7 A, 65 W max.

Output voltage ranges:

0.01-1 V current capability 0-5 A
0.1-10 V current capability 0-1 A
1-100 V current capability 0-100 mA
10-1000 V current capability 0-10 mA

Above output voltage ranges and maximum current capabilities for each range apply in full for either dc or ac operation.

Output current ranges: (5 A maximum output)

1-100 μA voltage capability 0-500 V (uncalibrated in AC)
0.01-1 mA voltage capability 0-500 V
0.1-10 mA voltage capability 0-500 V
1-100 mA voltage capability 0-50 V
0.01-1 A voltage capability 0-5 V
0.1-10 A (5 A max output) voltage capability 0-0.5 V

Above output current ranges and maximum voltage capabilities for each range apply in full for either dc, 50 Hz or 60 Hz operation.

Output accuracy: DC—0.2% of set value plus 1 digit. AC—0.4% of set value plus 1 digit (when used with average reading meters). Above accuracy applicable over a temperature range from 15°C to 35°C, over full input voltage range, and after 1 hour warmup.

Controls:

FUNCTION SWITCH—This is a 3-position switch: "OFF", "AC", and "DC". In the "OFF" position the ac power input is disconnected from the unit. In the "AC" position the meter calibrator produces an ac output; similarly, in the "DC" position the calibrator produces a dc output.

RANGE SWITCH—10 positions, one for each voltage and current range.

CALIBRATED OUTPUT CONTROL—Digital potentiometer readout control (3 significant digits) determines exact value of output.

OUTPUT SWITCH—Switch described at left.

Output terminals: two front panel terminals are provided; these are the output terminals for both ac and dc operation. In voltage ranges, the negative terminal is grounded.

Ripple: in dc operation the output ripple is typically less than 1.0% rms/5% p-p of the output range switch setting.

Operating temperature range: 0-50°C.

Size: 6¾" (172 mm) H x 7-13/16" (198 mm) W x 11" (279 mm) D.

Weight: 15 lbs (6,8 kg) net, 17 lbs (7,71 kg) shipping.

Price: $750.

Option 005: 50 Hz output regulation realignment, add $25.

Option 028: 230 V ac ±10%, single phase input, add $10.

DC STANDARD/Δ VOLTMETER

Ultra stable, high resolution dc calibration source

Model 740B

740B

Period	Zero stability ppm of range	Voltage stability (excludes zero stability) setting + range
1 hr	±1 ppm	±(0 ppm + 1 ppm)
24 hr	±2 ppm	±(5 ppm + 1 ppm)

Temperature coefficient

10°C to 40°C: <±0.0002% of setting/°C or ±0.0001% of range/°C, whichever is greater.

Line regulation: <±(0.0005% of setting +0.0001% of range) for 10% line voltage change.

Load regulation (no load to full load): <(0.0005% of setting +10 μV).

Output characteristics

Output current: maximum output current 50 mA at 1 V output, decreasing linearly to 20 mA at 1000 V output. Current limiter continuously adjustable from 10% to 100% of maximum output current.

Output resistance: <(0.0002 +0.0001 E_{out})Ω.

Noise (rms value)

Range	0.01 Hz – 1 Hz	1 Hz – 1 MHz
1 V	<1 μV	<100 μV
10 V	<10 μV	<100 μV
100 V	<100 μV	<1 mV
1000 V	<1 mV	<10 mV

DC differential voltmeter

Ranges

Voltage: 1 mV to 1000 V† in 7 decade ranges.

Resolution: 6-digit readout yields resolution of 0.0001% of range (6th digit indicated on meter).

Performance

Accuracy: (<70% RH, constant line and temperature ±1°C. Calibrated at factory at 115 V and 23°C.)

30 day: ±(0.005% of reading +0.0004% of range ±1 μV).

90 day: ±(0.008% of reading +0.0004% of range +1 μV).

Stability: (<70% RH, constant line and temperature ±1°C):

Period	Zero stability	Reading stability (excludes zero stability) reading + range
1 hr	±(1 ppm of range + 1 μV)	±(0 ppm + 1 ppm)
24 hr	±(1 ppm of range + 2 μv)	±(6 ppm + 1 ppm)

Temperature coefficient

10°C to 40°C: <±(0.0002% of reading +1 μV)/°C.

Line regulation: <±(0.001% of reading +2 μV) for 10% line voltage change.

Input characteristics

Input resistance: (independent of null).

100 mV to 1000 V ranges: >10^{10}Ω.

10 mV range: >10^{9}Ω.

1 mV range: >10^{8}Ω.

Effective common-mode rejection (ECMR): >120 dB, at and above 60 Hz.

Normal-mode rejection (NMR): >100 dB, at and above 60 Hz.

DC voltmeter

Voltage ranges: 1 μV to 1000 V† in 10 decade ranges.

Accuracy: ±(2% of range +0.1 μV).

Input resistance: 100 mV to 1000 V range: >10^{10}Ω; 10 mV range: >10^{9}Ω; 1 μV to 1 mV range: 10^{8}Ω.

Zero drift: <2 μV per day; zero control limits: >±10 μV.

Normal-mode rejection: same as dc differential voltmeter.

DC amplifier

Voltage gain: 1 mV range, 60 dB; 10 mV range, 40 dB; 100 mV range, 20 dB; 1 V to 1000 V ranges, 0 dB.

Gain accuracy: ±(0.01% of input +0.0005% of range +2 μV) referred to input.

Linearity: ±0.002% on any range.

Stability, temperature coefficient, line regulation, input resistance, ECMR, NMR: same as dc differential voltmeter.

Load regulation, output current, and output resistance: same as dc standard.

General

Operating temperature: 10°C to 40°C unless specified otherwise.

Storage temperature: −40°C to +65°C.

RFI: meets MIL-I-6181D.

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 100 VA max.

Dimensions: full module, 16¾" wide, 6⅞" high, 18¼" deep. (425 x 175 x 464).

Weight: net, 47.3 lbs (21,3 kg); shipping, 64 lbs (28,8 kg).

Accessories furnished

11054A input cable assembly; 11055B output cable assembly.

Price: HP 740B, $2995.

† Maximum of −500 V dc with respect to line ground can be applied to or obtained from the HP 740B.

* Refer to data sheet for complete specifications.

AC CALIBRATION SYSTEM

Precision source; to 1100 V; 10 Hz to 110 kHz

Models 745A & 746A

Description

The 745A AC Calibrator combined with the 746A High Voltage Amplifier, is a compact, calibrated ac source with a continuously-adjustable frequency output from 10 Hz to 110 kHz. The output can be varied from 0.1 mV to 1099.999 V in steps of 1 ppm of range over the entire frequency band.

The Model 745A provides the first six voltage ranges, 0.1 mV to 109.9999 V, while the combination of the 745A and 746A permits the expansion to 1099.999 V as a seventh range. The model 745A/746A voltage range, frequency range and error range are programmable through a rear-panel connector by transistor or switch closures to ground.

745A/746A Combined Specifications

Ranges

Output voltage ranges: 7 ranges with 10% overrange as follows:

Range	Settability and Resolution
1 mV	0.100000 mV to 1.099999 mV in 1 nV steps
10 mV	1.00000 mV to 10.99999 mV in 10 nV steps
100 mV	10.0000 mV to 109.9999 mV in 100 nV steps
1 V	0.100000 V to 1.099999 V in 1 μV steps
10 V	1.00000 V to 10.99999 V in 10 μV steps
100 V	10.0000 V to 109.9999 V in 100 μV steps
1000 V	100.000 V to 1099.999 V in 1 mV steps

The output voltages from 100 μV to 110 V are available from 745A output terminals; voltages from 100 V to 1100 V are available from the 746A output cable.

Output frequency range: continuously adjustable from 10 Hz to 110 kHz in 4 decade ranges with 10% overlap.

Error measurement: 2 ranges with zero center dial; ±0.3%, ±3%. A zero range is provided to switch out the effects of the error measurement system.

Performance rating

Accuracy: accuracy holds for a 90-day period and is met after a 1-hr warmup period at 25°C ±5°C with <95% RH. This applies only to the 745A. 746A warmup time required is approximately 30 s.

Voltage: specifications are absolute, traceable to the National Bureau of Standards.

1 mV to 100 V ranges:

Frequency	Accuracy
50 Hz to 20 kHz	±(0.02% of setting +0.002% of range +10 μV)
20 Hz to 50 Hz 20 kHz to 110 kHz	±(0.05% of setting +0.005% of range +50 μV)
10 Hz to 20 Hz	±(0.2% of setting +0.005% of range +50 μV)

1000 V range:

Frequency	Accuracy
50 Hz to 20 kHz	±0.04% of setting
20 Hz to 50 Hz 20 kHz to 50 kHz	±0.08% of setting
50 kHz to 110 kHz	±0.15% of setting
10 Hz to 20 Hz	±(0.2% of setting +0.005% of range)

Frequency: ±(2% of setting +0.2% of end scale).

Error measurement: ±(0.5% of setting +0.5% of range).

Temperature coefficient

Voltage: 1 mV to 100 V ranges: ±0.0003% of setting per °C, 0°C to 55°C. 1000 V range: ±0.0005% of setting per °C, 0°C to 55°C.

Frequency: ±0.05% of end scale per °C, 0°C to 55°C. Derate accuracy specifications by this temperature coefficient for operation in temperature range of 0°C to 20°C and 30°C to 55°C.

*Refer to data sheet for complete specifications.

745A/746A

Voltage stability: stability met after 1-hr warmup period at constant temperature with <95% RH.

1 mV to 100 V ranges

Long-term: ±0.01% of setting for 6 mo.

Short-term: ±0.005% of setting for 24 hr.

1000 V range

Long-term: 50 Hz to 20 kHz: ±0.01% of setting for 6 mo. 10 Hz to 50 Hz and 20 kHz to 110 kHz: ±0.02% of setting for 6 mo.

Short-term: ±0.005% of setting for 24 hr.

Output characteristics*

Total distortion and noise: 0.05% of setting +10 μV over 100 kHz bandwidth on all ranges.

Load capability

1000 pF or 50 mA on 1V to 100 V ranges (50 mA allows 800 pF at 100 V, 100 kHz).

1000 pF or 63 mA on 1000 V range (63 mA allows 100 pF at 1000 V, 100 kHz).

Line regulation: ±0.001% of setting change in output voltage for 10% change in line voltage (included in accuracy spec).

General

Operating temperature: 0°C to 55°C.

Power: 745A: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 115 VA max. 746A: 115 V or 230 V ±10%, 50 Hz to 60 Hz, 1 kVA max. 746A aux power output rated at 120 VA max.

Dimensions: 745A: 16¾" wide, 8¾" high, 18⅜" deep (425 x 221 x 467 mm). 746A: 16¾" wide, 7" high, 18¼" deep (425 x 177 x 464 mm).

Weight: 745A: net, 65 lbs (29,3 kg); shipping, 81 lbs (36,5 kg). 746A: net, 75 lbs (34 kg); shipping, 93 lbs (41,9 kg).

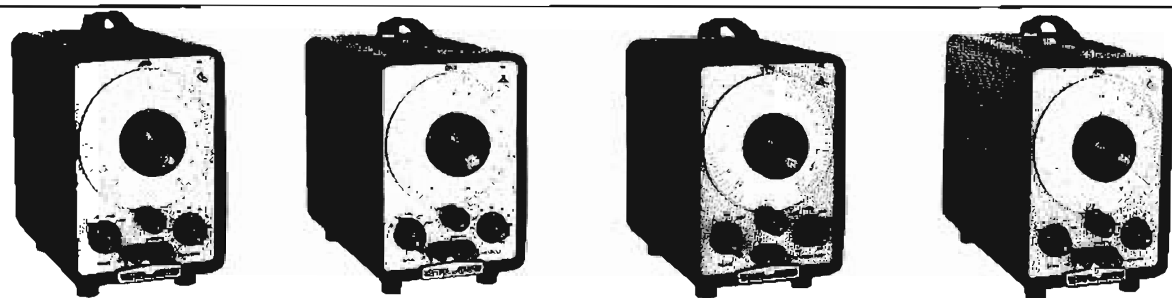
Accessories furnished

745A: rack mount kit; HP Part No. 5060-0630, 22-pin printed circuit board extender; HP Part No. 5060-0043, 15-pin printed circuit board extender; HP Part No. 5060-0031, 10-pin printed circuit board extender; HP Part No. 1251-0084 remote programming mating plug.

746A: accessory kit; HP Part No. 00746-84401; HP Part No. 1251-0485, remote right angle connector; HP Part No. 1450-0356, incandescent lamp; HP Part No. 4040-0427, extractor; HP Part No. 5040-0404, probe holder; HP Part No. 5060-0216, joining kit bracket; HP Part No. 5060-0630, 22-pin printed circuit board extender; 7H rack mounting kit; HP Part No. 00746-02701, foam filter.

Price: HP 745A, $3995; HP 746A, $2270.

AUDIO OSCILLATORS
Balanced, floating and single ended
Models 200AB, 200CD, 201C, 202C



200AB 200CD 201C 202C

Description

The Hewlett-Packard series oscillators have high stability and accurate, easily resettable tuning circuits. Low-impedance operating levels, together with superior insulation guarantee peak performance throughout years of trouble-free service. The instruments have a wide frequency range and long dial lengths and feature an improved vernier frequency control.

General

Rack models: 19" rack models also available. Order Models 200ABR, 200CDR, 201CR or 202CR. Add $5 to cabinet price listed in specification chart.

Accessories available: 11000A Cable Assembly, $13; 11001A Cable Assembly, $13; 11004A Line Matching Transformer, $65; 11005A Line Matching Transformer, $85.

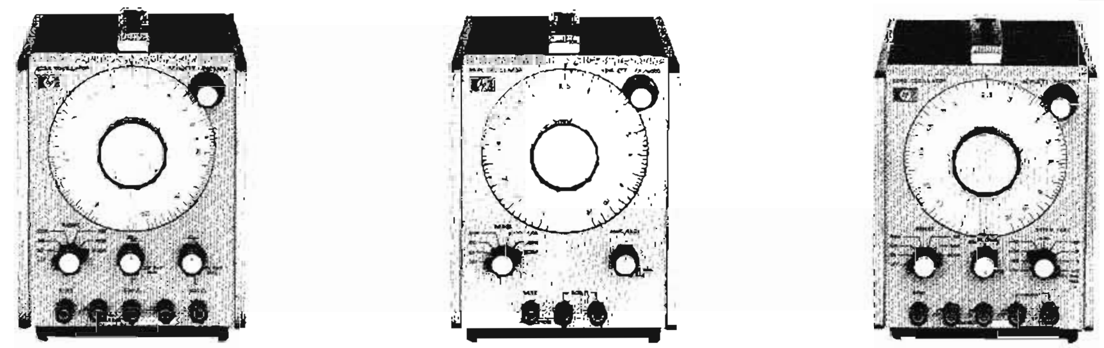
Specifications

	200AB	200CD	201C	202C
Frequency Range	20 Hz to 40 kHz	5 Hz to 60 kHz	20 Hz to 20 kHz	1 Hz to 100 kHz
Number of Ranges	4 overlapping	5 overlapping	3 overlapping	5 overlapping
Dial Accuracy	±2%	±2%	±1%	±2%
Frequency Response	±1 dB (1 kHz ref)	±1 dB (1 kHz ref)	±1 dB (1 kHz ref)	±1 dB (1 kHz ref)
Output (into 600Ω load)	1 W (24.5 V)	>160 mW (10 V) Opt. H20, 93 mW (7.5 V)	3 W (42.5 V)	160 mW (10 V)
Output Impedance	<75Ω from 20 Hz - 15 kHz	600Ω	600Ω ±10%, 20, 30 and 40 dB settings. <600Ω, 0 dB and 10 dB settings	600Ω
Output Balance	Balanced to ground and floating over entire frequency range.	Balance and floating. Better than 0.1% at lower frequencies and approx. 1% at higher frequencies	One terminal at ground potential	Balance and floating. Better than 0.1% at lower frequencies and approx. 1% at 100 kHz
Distortion	<1%, 20 Hz to 20 kHz <2%, 20 kHz to 40 kHz (into 600Ω load or higher impedance)	0.2%, 20 Hz to 200 kHz 0.5%, 5 Hz to 20 Hz and 200 kHz to 600 kHz Opt. H20: 0.06%, 60 Hz to 50 Hz. 0.1%, 20 Hz to 60 Hz and 50 kHz to 400 kHz. 0.5%, 5 Hz to 20 Hz and 400 kHz to 600 kHz.	<0.5%, 50 Hz to 20 kHz @ 1W <1%, 20 Hz to 20 kHz @ 3W	<0.5% above 5 Hz (independent of load impedance).
Hum and Noise	66 dB below maximum rated output	<0.1% of rated output	<0.03% of rated output	<0.1% of rated output
Attenuator	Bridged "T"	Bridged "T"	0 to 40 dB in 10 dB steps. Coarse and fine controls.	Bridged "T"
Input Power	115 or 230 V (must be specified) 50/400 Hz, 75 VA	115 or 230 V, 50 to 1000 Hz, 90 VA	115 or 230 V, 50 to 400 Hz, 75 VA	115 or 230 V, 48 Hz to 440 Hz, 90 VA.
Weight lbs (kg)	Net: 15 lbs (6,7 kg) Shipping: 16 lbs (7,2 kg)	Net: 22 lbs (9,9 kg) Shipping: 24 lbs (10,8 kg)	Net: 16 lbs (7,2 kg) Shipping: 19 lbs (8,6 kg)	Net: 25 lbs (11,3 kg) Shipping: 28 lbs (12,7 kg)
WxHxD Dimensions	7½ x 11½ x 12 (191 x 292 x 305)	7⅜ x 11½ x 14⅜ (187 x 292 x 365)	7½ x 11½ x 12½ (191 x 292 x 318)	7½ x 11½ x 14¼ (191 x 292 x 368)
Price	$270	$310 Opt. H20, $370	$330	$370

SINE, SQUARE OSCILLATORS

Low distortion; wide range; balanced output

Models 209A, 204C, 204D



209A 204C 204D

The HP 209A is a small, lightweight, sine/square oscillator. Stable, accurate signals which can be synchronized with an external source are instantly available over a frequency range from 4 Hz to 2 MHz. Separately adjustable sine/square outputs are located on the front panel. Distortion and flatness can be minimized at low frequencies by a rear panel LOW DISTORTION MODE switch.

The HP 204C is a small, lightweight capacitive-tuned oscillator. Interchangeable power packs, line, rechargeable batteries or mercury batteries make this instrument ideal for both field and laboratory use. Internal heat generation and temperature coefficient is small, resulting in unusually low drift. Stable, accurate signals which can be synchronized with an external source are instantly available over a frequency range from 5 Hz to 1.2 MHz. Distortion can be minimized at low frequencies by a rear panel Low Distortion Mode switch; however, settling time with a rapid frequency change is increased.

The HP 204D Oscillator is identical to the 204C with the addition of an 80 dB attenuator and vernier. The attenuator with the vernier provides excellent output amplitude settability.

Specifications (209A)

Frequency: 4 Hz to 2 MHz in 6 ranges.
Dial accuracy: ±3% of frequency setting.
Flatness: at maximum output into 600Ω load, 1 kHz reference.

Low distortion mode	±1%	±0.5%	±1%	±5%
Normal mode	+5%, −1%	±0.5%	±1%	±5%
	4	100	300k	1M	2M (Hz)

Distortion: 200 Hz to 200 kHz, 0.1% (−60 dB); 4 Hz to 200 Hz, <0.2% (−54 dB); 200 kHz-2 MHz, <1% (−40 dB).
Hum and noise: <0.01% of input.

Output characteristics sine wave

Output voltage: 5 V rms (40 mW) into 600Ω; 10 V open circuit.
Output impedance: 600Ω.
Output control: >26 dB range continuously adjustable.
Output balance: >40 dB below 20 kHz. Output can be floated up to ±500 V p between output and chassis ground.

Output characteristics square wave

Output voltage: 20 V p-p open circuit symmetrical about 0 V. Output can be floated up to ±500 V p.
Rise and fall time: <50 ns into 600Ω. Symmetry: ±5%.
Output impedance: 600Ω.

Synchronization

Sync output: sine wave in phase with output; 1.7 V rms open circuit (high end affected by capacitive loads); impedance 10 kΩ.
Sync input: same as 204C.
Price: HP 209A, $355.

Specifications (204C)

Frequency: 5 Hz to 1.2 MHz in 6 overlapping ranges.
Dial accuracy: ±3% of frequency setting.
Flatness (at maximum output into 600Ω load, 1 kHz reference)

Low distortion mode	±1%	±0.5%	±1%
Normal mode	+5%, −1%	±0.5%	±1%
	5	100	300k	1.2M (Hz)

Distortion: 30 Hz to 100 kHz, 0.1% (−60 dB); 5 Hz to 30 Hz, <0.6% (−44 dB); 100 kHz-1.2 MHz, linearly derated to <1%.
Hum and noise: <0.01% of output.

Output characteristics

Output voltage: >2.5 V rms (10 mW or +10 dBm) into 600Ω; >5 V rms open circuit.
Output impedance: 600Ω.
Output control: >40 dB range; continuously adjustable.
Output balance: >40 dB below 20 kHz. Can be floated up to ±500 V p between output and chassis ground.

Synchronization

Sync output: sine wave in phase with output; >100 mV rms into <100 pF over entire range; impedance 10 kΩ.
Sync input: oscillator can be synchronized to external signal. Sync range, the difference between sync frequency and set frequency, is a linear function of sync voltage. ±1%/V rms for sine wave with a maximum input of ±7 V p (±5 V rms).

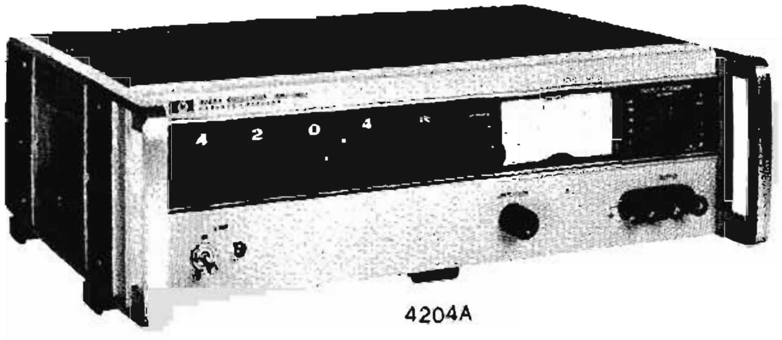
Specifications (204D)

(Identical to 204C except "output control" is replaced by the following:)
Output attenuator
Range: 80 dB in 10 dB steps.
Overall accuracy: ±0.3 dB, +10 dB through −60 dB ranges; ±0.5 dB on −70 dB range.
Output vernier: >10 dB range, continuously adjustable.

General

Operating temperature: specifications are met from 0°C to 55°C.
Power: standard: ac-line 115 V or 230 V ±10%, 48 Hz to 440 Hz, <7 VA max. Opt. 001: mercury batteries 300 hours operation. Opt. 002: line/rechargeable batteries 115 V or 230 V ±10%, 48 Hz to 440 Hz, <7 VA max. 35 hours operation per recharge.
Dimensions: 5⅛" wide, 6¼" high (without removeable feet), 8" deep (130 x 159 x 203 mm).
Weight: net 6 lbs (2,7 kg); shipping 9 lbs (4 kg).
Accessories available: HP 11135A AC Power Pack for 204C, $60. HP 11136A Mercury Power Pack for 204C, $75. HP 11137A Rechargeable Battery/AC Power Pack for 204C, $95. HP 11075A Instrument Case, $60.
Price: HP 204C (ac line), $260; HP 204D, $335; HP 204C or 204D option 001 (mercury batteries), add $15. HP 204C or 204D option 002 (rechargeable batteries, ac-line), add $35.

DIGITAL OSCILLATOR
Four digit frequency resolution, 10 Hz to 1 MHz
Model 4204A



4204A

Description

The Hewlett-Packard 4204A Digital Oscillator provides accurate, stable test signals for both laboratory and production work. This one instrument does the jobs of an audio oscillator, and ac voltmeter, and an electronic counter, in applications requiring an accurate frequency source of known amplitude.

Any frequency between 10.0 Hz and 999.9 kHz can be digitally selected with an in-line rotary switch. As many as 36,900 discrete frequencies are available. Infinite resolution is provided by one vernier control, which also extends the upper frequency limit to 1 MHz. Frequency accuracy is better than ±0.2% and repeatability is typically better than ±0.01%.

A built-in high impedance voltmeter measures the output. The meter is calibrated to read volts or dBm into a matched 600 ohm load. (0 dBm = 1 mW into 600 ohms). The output attenuator has an 80 dB range, adjustable in 10 dB steps with a 20 dB vernier. Maximum output power can be increased to 10 volts into 600 ohms (+22 dBm).

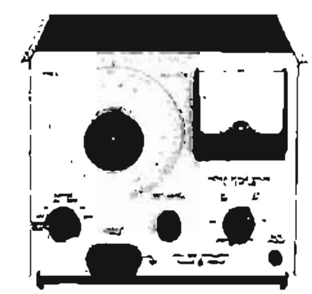
Specifications, 4204A

Frequency range: 10 Hz to 1 MHz, 4 ranges.
Frequency accuracy: ±0.2% or ±0.1 Hz (at 25°C).
Frequency stability
±10% line voltage variation: <±0.01%.
Change of frequency with temperature: <±100 ppm/°C.
Frequency response: flat within ±3%.
Output: 10 V (22 dBm) into 600Ω, (160 mW). 20 V open circuit.
Output attenuators: 80 dB in 10 dB steps: <±0.5 dB error.
Distortion: <0.3%, 30 Hz to 100 kHz. <1%, 10 Hz to 1 MHz.
Hum and noise: <0.05% of output.
Dimensions: cabinet, 5¼" high, 16¾" wide, 11¼" deep (134 x 426 x 286 mm).
Power: 115 V/230 V switch, ±10%, 11 VA max, 50 to 60 Hz.
Weight: net, 19 lbs (8.5 kg); shipping, 26 lbs (10,7 kg).
Price: HP 4204A, $910.
Option 001: output monitor top scale calibrated in dBm/600Ω; bottom scale calibrated in volts, add $20

TEST OSCILLATOR
Rechargeable battery operation
Model 208A

Specifications, 208A

Frequency range: 5 Hz to 560 kHz in 5 ranges. 5% overlap between ranges, vernier control.
Dial accuracy: ±3%.
Frequency response: ±3% into rated load.
Output: 10 mW nominal 2.5 V rms (+10 dBm) into 600Ω.
Output impedance: 600Ω.
Output attenuator (Option 001: 0 to 110 dB in 1 dB steps)
Meter scale value: 0.01 mV to 1 V full scale (6 steps).
Multiplier: 2.5 multiplier, concentric with Meter Scale Value switch, to obtain 0.025 mV to 2.5 V.
Output attenuator accuracy: 5 Hz to 100 kHz, error is <±3% at any step. From 100 kHz to 560 kHz, error is <5% at any step. Specifications include multiplier accuracy. (Option 001, see data sheet.)
Output monitor: transistor voltmeter monitors level at input to attenuator and after set level. Accuracy ±2% of full scale into 600Ω. (Option 001, accuracy ±0.25 dB at +10 dBm into 600Ω.)
Set level: continuously variable bridged "T" attenuator with 10:1 voltage range. (Option 001, 20 dB minimum range.)
Distortion: <1%.
Hum and noise: <0.05% at maximum output.



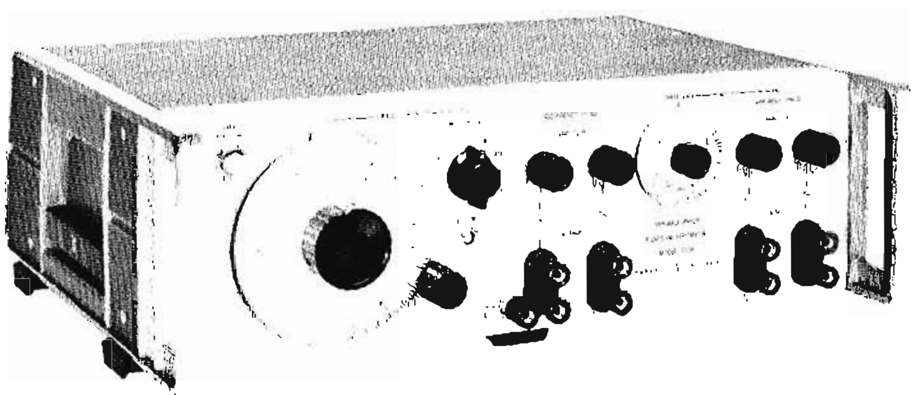
208A

Operating temperature range: 0°C to +50°C.
Power source: four rechargeable batteries (furnished); 30 hr operation per recharge. Oscillator may be operated during recharge from ac line (115 V or 230 V ±10%, 50 to 400 Hz, 3 W).
Dimensions: 7-25/32" wide, 6¼" high (without removable feet), 8" deep (197 x 155 x 203 mm).
Weight: net, 8¼ lbs (3,5 kg); shipping, 11 lbs (5 kg).
Price: HP 208A, $615. Option 001, add $15.

VARIABLE-PHASE GENERATOR

Sine- and square-waves 0.00005 Hz to 60 kHz

Model 203A



203A

The solid-state HP Model 203A Low-Frequency Function Generator provides two transient-free low-distortion square and sinusoidal test signals particularly useful for a wide variety of low-frequency applications. Field and laboratory testing of servo, geophysical, medical and high-quality audio equipment becomes practical when using the 203A.

The 203A frequency range of 0.005 Hz to 60 kHz is covered in 7 overlapping bands (2 additional ranges available on special order, offering frequency range to 0.00005 Hz). Accurate ±1% frequency setting is provided by 180 dial divisions. A vernier drive allows precise adjustment.

30 volt output

The 203A provides a maximum output voltage of 30 V peak-to-peak for all waveforms. The sinusoidal signals have a distortion that is less than 0.06% and provide virtually transient-free outputs when frequency and operating conditions are varied rapidly. The four output circuits of the 203A have individual 40 dB continuously variable attenuators.

Outputs consist of a reference sine and square wave, and a variable-phase sine and square wave. The two sine- and square-wave outputs are electrically identical except that one sine- and square-wave output contains a 0-to-360 degree phase-shifter. These four signals (two reference phase and two variable phase) are available simultaneously from the 203A. The output system is floating with respect to ground and may be used to supply an output voltage that is terminal grounded, or may be floated up to 500 volts dc above chassis ground. The output impedance is 600 ohms for all outputs.

Special features

A front-panel calibration provision permits the user to easily calibrate the oscillator frequency to the environment in which the instrument is used. The HP 203A features a unique method of mixing, filtering and dividing the frequency to maintain an exact decade relationship. Interchangeable decade modules provide greater reliability and ease of servicing.

Specifications, 203A

Frequency range: 0.005 Hz to 60 kHz in seven decade ranges.*

Dial accuracy: ±1% of reading.

Frequency stability: within ±1% including warmpp drift and line voltage variations of ±10%.

Output waveforms: sine and square waves are available simultaneously; all outputs have common chassis terminal.

Reference phase: sine wave, 0 to 30 V peak-to-peak; square wave, 0 to 30 V peak-to-peak (open circuit).

Variable phase: sine wave, 0 to 30 V peak-to-peak; square wave, 0 to 30 V peak-to-peak; continuously variable, 0 to 360°; phase dial accuracy, ±5° sine wave, ±10° square wave (open circuit).

Output impedance: 600 ohms.

Output power: 5 volts into 600 ohms (40 mW); 40 dB continuously variable attenuation on all outputs.

Distortion: total harmonic distortion hum and noise >64 dB below fundamental (<0.06%) at full output.

Output system: direct-coupled output is isolated from ground and may be operated floating up to 500 V dc.

Frequency response: ±1% referenced to 1 kHz.

Square wave response: rise and fall time, <200 ns; overshoot, <5% at full output.

Power: 115 or 230 volts ±10%, 48 to 440 Hz, 27.5 VA max.

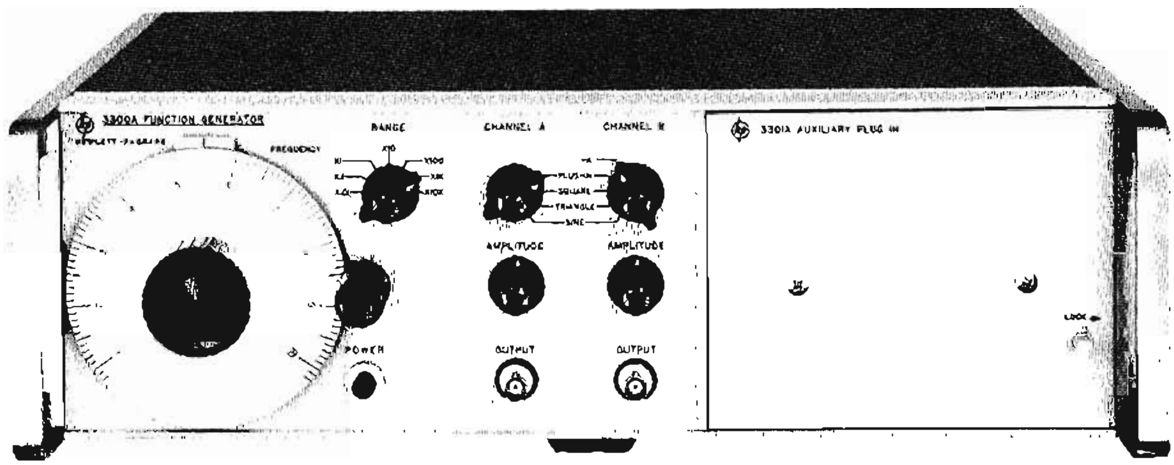
Dimensions: cabinet: 5¼" high, 16¾" wide, 11½" deep (133 x 425 x 286 mm); rack mount kit(00203-84401) furnished with instrument.

Weight: net, 20 lbs (9,17 kg); shipping, 28 lbs (12,6 kg).

Price: HP 203A, $1465; Option 001 (0.0005 Hz range), add $65; Option 002 (0.00005 Hz range), add $190.

*Two lower ranges of 0.0005 Hz (Option 001) and 0.00005 Hz (Option 002) are available on special order.

FUNCTION GENERATOR
Multiple outputs, plug-in versatility
Model 3300A & 3301A plug-in



3300A/3301A

Description

Plug-ins and multiple outputs set the HP 3300A Function Generator apart from other function generators. Any two of three waveforms—sine, square or triangular—may be selected by a front-panel switch over the frequency range from 0.01 Hz to 100 kHz, continuously adjustable in seven decade ranges. This solid-state, multi-purpose source provides simultaneous signals of any two waveforms over the entire frequency range with independent variable amplitudes.

Plug-ins, which insert directly into the front panel, include the HP 3301A Auxiliary Plug-in to provide internal connections for basic unit operation. The 3302A plug-in provides single and multiple-cycle operation with adjustable start-stop phase. A phase-lock loop in the 3302A permits synchronizing the 3300A with an external signal and gives adjustable phase control. The HP 3304A Sweep/Offset Plug-in provides internal sweeping, dc offset, sawtooth waves and offset square waves. The 3305A Sweeper Plug-in supplies internal log sweep and manual sweep over four decades with calibrated variable start-stop frequency control within four decades. Sweep width is continuously-adjustable. It has manual or external triggering. Sweep can be analog-programmed with horizontal sweep available for driving scopes or recorders.

The frequency of the HP 3300A can be controlled by either the front-panel frequency dial or an external voltage applied to a rear-terminal connector. This feature is useful for sweeping filters, amplifiers and other frequency-dependent devices and for externally programming frequencies for production testing.

The output system of the HP 3300A is dc coupled and fully floating with respect to power-line ground. An internal shield reduces radiated interference and provides common-mode rejection with floating output. A balanced output can be obtained by using both output amplifiers. Each output amplifier will deliver 35 V p-p into an open circuit.

Specifications

Output waveforms: sinusoidal, square and triangular selected by panel switch (any two outputs available simultaneously).

Frequency range: 0.01 Hz to 100 kHz in 7 decade ranges.

Typical frequency stability
- **Short term:** drift $<\pm 0.05\%$ of setting for 10 min.
- **Long term:** drift $<\pm 0.25\%$ of setting for 24 hrs.

Frequency response: $\pm 1\%$, 0.01 Hz to 10 kHz; $\pm 3\%$, 10 kHz to 100 kHz on the X10 k range.

Dial accuracy: $\pm 1\%$ of maximum dial setting (1 minor division), 0.01 Hz to 10 kHz at $+25°C$; $\pm 2\%$ of maximum dial setting (2 minor divisions), 10 kHz to 100 kHz on the X10 k range.

Maximum output per channel: >35 V p-p open circuit; >15 V p-p into 600Ω; >2 V p-p into 50Ω.

Output attenuators (both channels): 40 dB range.

Sine-wave distortion: $<1\%$, 0.01 Hz to 10 kHz; $<3\%$, 10 kHz to 100 kHz on the X10 k range.

Square-wave response: <250 ns rise and fall time on all ranges; $<1\%$ sag, $<5\%$ overshoot at full output; $<1\%$ symmetry error; <500 ms rise and fall time (—A).

Triangle-linearity error: $<1\%$, 0.01 Hz to 10 kHz; $<2\%$, 10 kHz to 100 kHz at full output; $<1\%$ symmetry error.

Sync-pulse output: >10 V p-p open circuit, <5 μs duration.

Output impedance (both channels): 600Ω $\pm 20\%$.

DC stability: drift $<\pm 0.25\%$ of p-p amplitude over a period of 24 hours (after 30-min. warmup).

Remote frequency control: 0 to -10 V will linearly change frequency >1 decade within a single range. Frequency resettability with respect to voltage $\pm 1\%$ of maximum frequency on range selected.

Power: 115 or 230 V $\pm 10\%$, 48 to 440 Hz, 65 VA max.

Dimensions: standard Hewlett-Packard full module 16¾" wide, 5-7/32" high, 11" deep (425 x 133 x 279 mm).

Weight: net, 20 lbs (9 kg); shipping, 25 lbs (11,3 kg).

Accessories furnished: rack mount kit for 19" rack.

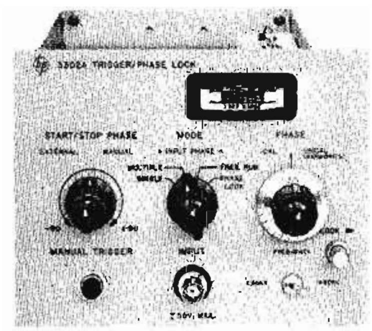
Plug-ins available
- HP 3301A Auxiliary Plug-in, $35.
- HP 3302A Trigger/Phase Lock Plug-in (see page 322).
- HP 3304A Sweep/Offset Plug-in (see page 322).
- HP 3305A Sweeper Plug-in (see page 322).

Price: HP 3300A Function Generator, $775.

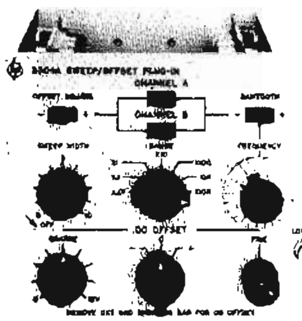
PLUG-INS FOR 3300A

Lin/log sweep, phase lock, dc offset

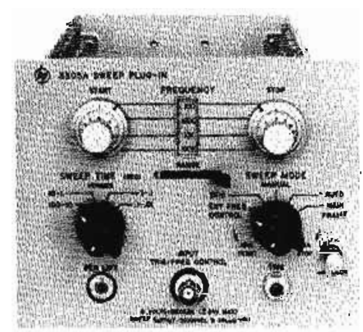
Models 3302A, 3304A, 3305A



3302A



3304A



3305A

The HP 3302A Trigger/Phase Lock Plug-in provides single-cycle, multiple-cycle, and phase-lock operation. The instrument can be triggered over the entire frequency range, either manually or by applying an external voltage.

The HP 3304A Sweep/Offset Plug-in provides internal sweeping, dc offset, sawtooth waves, and offset square waves. Up to ±16 V of dc offset is available for all signals generated in the main frame and plug-in. In addition, the independently frequency-controlled sawtooth wave may be switched internally to the frequency control circuit of the HP 3300A Function Generator to permit sweeping over a decade of frequency within a single range.

The HP 3305A Sweep Plug-in will sweep logarithmically, repetitively between any two frequencies within one of the three (4-decade) ranges: 0.1 Hz to 1 kHz, 1 Hz to 10 kHz, and 10 Hz to 100 kHz. Calibrated independent START-STOP controls greatly simplify setting desired sweep end points. Adjustable sweep time, from 0.01 to 100 seconds, provides sweep times slow enough for accurate response testing of low-frequency high-Q systems and fast enough for good visual displays of higher frequency responses.

Specifications, 3302A

Trigger requirements

Single cycle: manual or external, dc coupled. Requires at least 0.5 V to trigger externally. May be triggered with positive or negative input voltage which starts at or goes through 0 V (±20 V p max.).

Multiple cycle: manual or external start/stop, dc coupled. Requires at least 0.5 V to start, 0 V to stop. May be triggered with either positive or negative (±20 V p max.).

Phase lock: 10 Hz to 100 kHz (upper 4 ranges only), dc coupled. Requires + and −0.5 V p to lock, 10 V p-p for specified accuracy with sine wave input. The 3302A will lock on a fundamental or harmonic of the input signal.

Phase dial accuracy: ±10° from 10 Hz to 10 kHz; ±20° from 10 kHz to 100 kHz on X10 k range (fundamental).

Introduced distortion: <1%, 10 Hz to 10 kHz; <3%, 10 kHz to 100 kHz on X10 k range (fundamental).

Specifications, 3304A

DC offset

Voltage range: adjustable 0 to ±16 V open circuit and ±1 V vernier.

DC stability: ±50 mV over 24-hr period (after 30-min. warm-up).

Offset square wave

Output polarity: positive or negative, from dc offset voltage or ground potential.

Amplitude: >15 V p-p open circuit; continuously adjustable with 3300A amplitude control. Rise time: <400 ns. Overshoot: <5% at full output. Sag: <1%.

Sawtooth waveform

Frequency range: 0.01 Hz to 100 kHz, continuously adjustable over 7 decade ranges.

Dial accuracy: <±10% full scale, 0.01 Hz to 1 Hz; <±5% full scale, 1 Hz to 100 kHz.

Amplitude: >15 V p-p open circuit; continuously adjustable over a 40 dB range with 3300A amplitude control.

Frequency response: <2%, 0.01 Hz to 10 kHz; <5%, 10 kHz to 100 kHz.

Output polarity: positive or negative, from dc offset voltage or ground potential.

Linearity: <1%, 0.01 Hz to 10 kHz; overshoot, <5%.
<2%, 10 kHz to 100 kHz; overshoot, <5%.

Flyback time: <5% +250 ns.

Internal sweep

Controls: start frequency set by 3300A frequency dial; sweep range set by sweep width control on plug-in.

Sweep rate: determined by sawtooth frequency setting.

Sweep width: adjustable from 0 to at least 1 decade on any one range.

Specifications, 3305A

Frequency range: 0.1 Hz to 100 kHz in 3 overlapping ranges.

Sweep width: limits adjustable 0 to 4 decades in any of 3 (4-decade) bands: 0.1 Hz to 1 kHz, 1 Hz to 10 kHz, 10 Hz to 100 kHz. Start-stop dial accuracy: ±10% of setting.

Sweep modes

Automatic: repetitive logarithmic sweep between start and stop frequency settings.

Manual: vernier adjustment of frequency between start and stop frequency settings.

Trigger: sweep between start and stop frequency settings and retrace with application of external trigger voltage or by depressing front-panel trigger button.

Trigger requirements: ac coupled, positive going at least 1 V p with >2 V per ms rise rate. Max. input, ±90 V p.

Sweep time: 0.01 s to 100 s in 4 decade steps, continuously adjustable vernier.

Retrace time: <0.003 s for 0.1 to 0.01 s sweep times; <0.03 s for 1 to 0.1 s sweep times; <4 s for 100 to 1 s sweep times.

Blanking: oscillator disabled during retrace.

Pen lift: terminals shorted during sweep; open during retrace in auto and trigger modes for 100 to 1 s sweep times.

Sweep output: linear ramp at CHANNEL B OUTPUT (PLUG-IN); amplitude adjustable independently of sweep width; max. output >15 V p-p into open circuit, >7 V p-p into 600Ω.

External frequency control

Sensitivity: 6 V/decade (refer: START setting), ±24 V max.

V-to-F conversion accuracy: for each 6 V change in programming voltage, frequency changes 1 decade ±5% of end F.

Input impedance: 400 kΩ ±5%. Max. rate: 100 Hz.

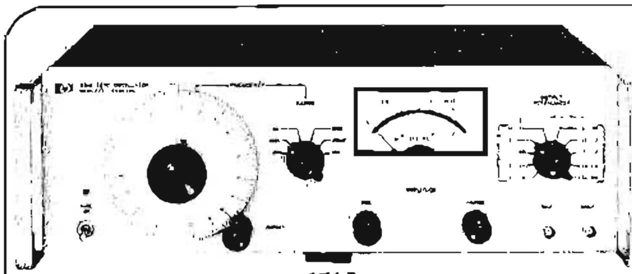
General

Dimensions: 6-1/16" wide, 4¾" high, 10¼" deep (154 x 121 x 260 mm).

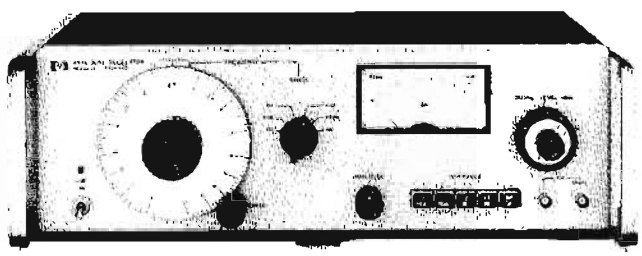
Weight: net 4 lbs 6 oz (2 kg); shipping 8 lbs (3,6 kg).

Price: HP 3302A, $255; HP 3304A, $295; HP 3305A, $1015.

TEST OSCILLATORS
10 Hz to 10 MHz; 2%/mo amplitude stability
Models 651B, 652A, 654A



651B



654A

Description

Amplitude and frequency stability of the 651B Test Oscillator provides test quality signals for laboratory or production measurements from 10 Hz to 10 MHz. Two output impedances are available from the front panel providing 200 mW into 50Ω or 16 mW into 600Ω.

The 652A is the same as the 651B with the addition of an expandable monitor for amplitude control to 0.25% across the band.

The 654A Test Oscillator is a lightweight, portable solid-state signal source. Its 10 Hz to 10 MHz frequency band, amplitude stability, accuracy, and level flatness make it an ideal general purpose test oscillator. The selective output impedances of 50Ω, 75Ω unbalanced, and 135Ω, 150Ω, 600Ω balanced make it useful in electronic research laboratories, in production testing, and for use as a commercial test instrument.

651B Specifications*

Frequency range: 10 Hz to 10 MHz, 6 band, dial calibration: 1 to 10.

Amplitude stability: ±2% per mo., 20°C - 30°C.

Dial accuracy (including warmup and ±10% line voltage variations): ±2%, 100 Hz to 1 MHz; ±3%, 10 Hz to 100 Hz and 1 MHz to 10 MHz.

Output (max): 3.16 into 50Ω or 600Ω; 6.32 open circuit.

Ranges: 0.1 mV to 3.16 V full scale, 10 steps in 1, 3, 10 sequence: −70 dBm to +23 dBm (50Ω output) full scale, 10 dBm per step; coarse and fine adjustable.

Flatness

Amplitude not readjusted to a reference on the output monitor: ±2%, 100 Hz to 1 MHz; ±3%, 10 Hz to 100 Hz; ±4%, 1 MHz to 10 MHz**.

Amplitude readjusted to a reference on the output monitor:

Range	Frequency 10 Hz – 20 Hz	20 Hz – 4 MHz	4 MHz – 10 MHz
3 V and 1 V	2%	1%	2%
.3V to .3 mV	2.5%	1.5%	2.5%
.1 mV	3%	2%	3%

Distortion: <1%, 10 Hz to 2 MHz; <2%, 2 MHz to 5 MHz; <4%, 5 MHz to 10 MHz.

Attenuator

Range: 90 dB in 10 dB steps.

Accuracy: ±0.075 dB, −60 dBm to +20 dBm; ±0.2 dB, −70 dBm to −60 dBm.

Amplitude control: 20 dB range, coarse and fine.

Temperature range: 0°C to +50°C.

Power: 115 or 230 V ±10%, 48 Hz to 440 Hz, 35 VA max.

Dimensions: 16¾″ wide, 5-7/32″ high, 13¼″ deep.

Weight: net, 17 lbs (7,7 kg); shipping, 22 lbs (9,9 kg).

Accessory furnished: rack mount kit for 19″ rack.

Price: HP 651B, $660.

Option 001: output monitor reads dBm for 600Ω, add $30.

Option 002: outputs, 75Ω and 600Ω; in dBm/75Ω, add $30.

Note: other output impedances above 50Ω are available.

652A Specifications*

(Same as Model 651B except as indicated below)

Expand scale: expands reference voltage of the normal scale from 0.9 to 1.0 or 2.8 to 3.2.

Flatness (amplitude readjusted using expanded scale on output monitor: ±0.25% 3 V and 1 V range; ±0.75% 0.3 V to 0.3 mV range; ±1.75% 0.1 mV range.

Accessories furnished: HP 11048B 50Ω feed-thru termination; rack mounting kit.

Price: HP 652A, $795.

654A Specifications*

Frequency range: 10 Hz to 10 MHz in 6 bands.

Frequency accuracy: 100 Hz to 5 MHz, ±2%; 10 Hz to 100 Hz, ±3%; 5 MHz to 10 MHz, ±4%.

Level flatness (+10 dBm and 0 dBm): ±0.5% from 10 Hz to 10 MHz for unbalanced outputs, 10 Hz to 5 MHz for 135Ω and 150Ω outputs, and 10 Hz to 1 MHz for 600Ω output.

Output impedance: 50Ω unbalanced, 75Ω unbalanced, 135Ω balanced, 150Ω balanced, and 600Ω balanced.

Output level: +11 dBm to −90 dBm, 10 dB and 1 dB steps with adjustable ±1 dB meter range; calibrated for each impedance.

Attenuator

Range: 99 dB in 10 dB and 1 dB steps.

Accuracy: ±1.5% (0.15 dB) except ±10% (1 dB) at output levels below 60 dBm at frequencies >300 kHz.

Amplitude accuracy: ±1% for 90 days (1 kHz +10 dBm).

Meter tracking: ±0.05 dB.

Balance (on balanced impedances): >50 dB for frequencies from 10 Hz to 1 MHz, >40 dB to 5 MHz.

Distortion (THD): 10 Hz to 1 MHz, >40 dB below fundamental; 1 MHz to 10 MHz, >34 dB below fundamental.

Operating temperature: 0°C to +55°C (32°F to 130°F).

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 35 VA max.

Dimensions: 16¾″ wide, 5-7/32″ high, 11¼″ deep (425 x 133 x 286 mm).

Weight: net, 21 lbs (9,5 kg); shipping, 23 lbs (10,4 kg).

Accessories furnished: rack mounting kit for 19″ rack.

Accessories available: 11143A Balanced Cable, 44″ overall length (BNC to clip lead), $25.

Price: HP 654A, $960.

* Refer to data sheet for complete specifications.
** The response above 1 MHz at 600Ω output is affected by capacitive loads.

FUNCTION GENERATORS
Compact, 7 functions, 10 decades of frequency
Model 3310A/B

Description
The 3310A Function Generator is a compact voltage-controlled generator with 10 decades of range. Ramp and pulse functions in addition to sine, square and triangle plus dc offset and external voltage control provide wide versatility. Also on the front panel is the fast rise time sync output, square wave in symmetrical functions and rectangular in pulse and ramp. Aspect ratio of non-symmetrical function is 15%/85%.

The 3310B has all the features of the standard 3310A plus single and multiple cycle output capability. With the start/stop phase knob in the detent position (max ccw) the instrument has the same specifications as the standard 3310A. When the start/stop phase knob is out of the detent, single or multiple cycle outputs can be obtained using either manual or external triggering.

Specifications (3310A)
Output waveforms: sinusoidal, square, triangle, positive pulse, negative pulse, positive ramp and negative ramp. Pulses and ramps have a 15% or 85% duty cycle.

Frequency range: 0.0005 Hz to 5 MHz in 10 decade ranges.

Sine wave frequency response

0.0005 Hz to 50 kHz: ±1%; 50 kHz to 5 MHz: ±4%. Reference, 1 kHz at full amplitude into 50Ω.

Dial accuracy

0.0005 Hz to 500 kHz all functions: ±(1% of setting +1% of full scale).

500 kHz to 5 MHz sine, square and triangle: ±(3% of setting +3% of full scale).

500 kHz to 5 MHz pulse and ramps: ±(10% of setting +1% of full scale).

Maximum output on HIGH: >30 V p-p open circuit; >15 V p-p into 50Ω (except for pulses at frequency >2 MHz).

Pulse (frequency >2 MHz): >24 V p-p open circuit; >12 V p-p into 50Ω.

Minimum output on LOW: <30 mV p-p open circuit; <15 mV p-p into 50Ω.

Output level control: range >30 dB. HIGH and LOW outputs overlap for a total range of >60 dB; LOW output is 30 dB down from HIGH output.

Sine wave THD (below fundamental)

0.0005 Hz to 10 Hz: >40 dB (1%).

10 Hz to 50 kHz (on 1 k range): >46 dB (0.5%).

50 kHz to 500 kHz: >40 dB (1%).

500 kHz to 5 MHz: >30 dB (3%).

Square wave and pulse response: <30 ns rise and fall times at full output; <35 ns rise and fall times with AMPLITUDE control not fully CW; <5% total aberrations.

Triangle and ramp linearity: 0.0005 Hz to 50 kHz, <1%.

Triangle symmetry: 0.0005 Hz to 20 Hz: <1%; 20 Hz to 50 kHz: <0.5%.

Impedance: 50Ω.

Sync

Amplitude: >4 V p-p open circuit, >2 V p-p into 50Ω.

Rise and fall times: <20 ns.

Waveform: square for symmetrical functions, rectangular for pulse and ramp.

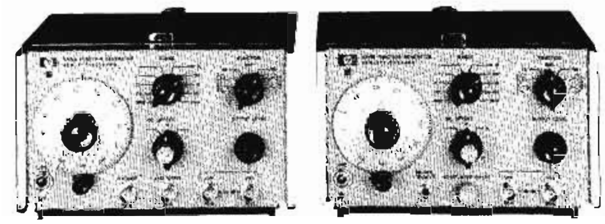
Output impedance: 50Ω.

Offset

Amplitude: ±10 V open circuit, ±5 V into 50Ω, continuously adjustable.

Note: max V ac p +V dc offset is ±15 V open circuit; ±7.5 V into 50Ω.

External frequency control range: 50:1 on any range.



3310A 3310B

Input requirement: with dial set to low end mark, a linear positive ramp of 0 to +10 V ±1 V will linearly increase frequency 50:1. With dial set at 50, a linear negative ramp of 0 to −10 V ±1 V will linearly decrease frequency 50:1. An ac voltage will FM the frequency about a dial setting within the limits (1 <f <50) x range setting.

Linearity: ratio of output frequency to input voltage $\left(\frac{\Delta F}{\Delta V}\right)$ will be linear within 0.5%.

Sensitivity: approximately 100 mV/minor division.

Input impedance: 10 kΩ.

Note: specifications apply from 5 to 50 on the frequency dial.

General
Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 32 VA max.

Dimensions: 7¾" wide, 4½" high (without removable feet) 8" deep (197 x 114 x 203 mm).

Weight: net, 6 lbs (2,7 kg); shipping, 10 lbs (4,5 kg).

Accessories available

HP Part No. 5060-0105 filler strip for use with HP 1051A combining case or HP 5060-0797 rack adapter frame.

Price: HP 3310A, $595.

Specifications (3310B)
Specifications for 3310B are same as 3310A with the addition of the following:

Modes of operation: free run, single cycle, multiple cycle.

Frequency range: 0.0005 Hz to 50 kHz (usable to 5 MHz).

Single cycle:** EXT TRIGGER (ac coupled) requires a positive-going square wave or pulse from 1 V p-p to 10 V p-p of lower frequency than that set on the 3310B; the triggering signal can be dc offset, but (V ac peak + V dc) ≤±10 V. EXT GATE (dc coupled) will trigger a single cycle on any positive waveform ≥1 V but ≤10 V which has period greater than the period of the 3310B output, and a duty cycle less than the period of the 3310B output. The gate signal cannot exceed 10 V.

Multiple cycle:** MANUAL TRIGGER will cause the 3310B to free run when depressed. When the trigger button is released, the waveform will stop on the same phase as it started. EXT GATE will cause the 3310B to free run when the gate is held at between +1 and +10 V. When the gate signal goes to zero, the 3310B will stop on the same phase as it started. For accurate gating, a square wave or square pulse is recommended.

Start-stop phase: The start-stop phase can be adjusted over a range of approximately ±90° using the front panel control.

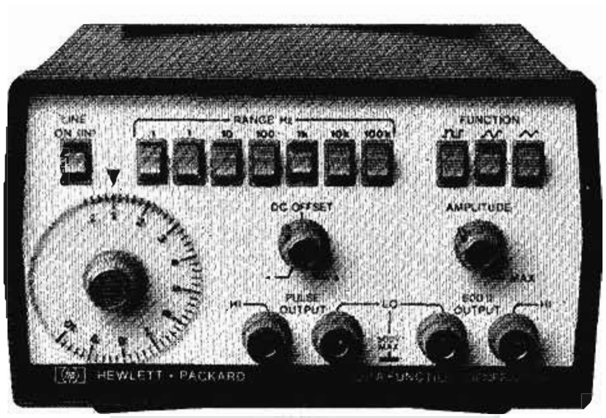
Input impedance: EXT TRIGGER: 390 pF in series with 500Ω. EXT GATE: 500Ω.

Price: HP Model 3310B, $735.

** This specification applies on the X.0001 to X1 k range only.

LOW COST FUNCTION GENERATOR
Seven decades of frequency, four functions
Model 3311A

NEW▶



3311A

Description

The 3311A Function Generator offers wide functional capability at a modest price. This compact unit has seven decades of range from 0.1 Hz to 1 MHz. Pushbutton range and function selection add convenience to versatility. Added features normally not found on function generators in this price range are 10:1 voltage control and a separate pulse output suitable for synchronization or driving TTL logic circuits.

Output

10 V p-p into 600Ω (20 V p-p O.C.). This output may be attenuated by >30 dB by a variable attenuator and offset by ±5 V. The dc offset allows the sine, square, and triangle functions to be positioned to the most desired level. This feature adds to the usefulness of all three functions.

V.C.O.

The dc coupled voltage control allows the use of an external source to sweep the 3311A >10:1 in frequency. An ac voltage can be used to FM the function generator.

Pulse output

A separate TTL compatible pulse output provides current sinking for up to 20 TTL loads. The pulse has a 15/85 aspect ratio with a <25 ns rise time.

Specifications

Waveforms: sinusoid, square, triangle, and positive pulse.

Frequency range: 0.1 Hz to 1 MHz in seven decade ranges.

Dial accuracy: ±5% of full scale.

Isolation: using an external supply, the outputs may be floated up to ±500 V relative to the instrument case (earth ground).

600 Ohm Output

Maximum output amplitude: 20 V p-p open circuit; 10 V p-p into 600Ω.

Amplitude control: continuously variable, >30 dB range.

DC offset: up to ±10 V open circuit, ±5 V into 600Ω, continuously adjustable and independent of amplitude control. Maximum V_{ac} peak + V_{dc} offset without clipping is ±10 V open circuit, ±5 V into 600Ω.

Output impedance: 600Ω ±10%.

Sine wave amplitude flatness: within ±3% of 10 kHz reference (maximum output amplitude) to 100 kHz, ±6% to 1 Hz.

Sine wave total harmonic distortion: <3% (maximum output amplitude).

Triangle linearity: deviation <1% from best straight line at 100 Hz (maximum output amplitude).

Square wave transition time: rise time: <100 ns; fall time: <100 ns.

Square wave time axis symmetry error: ±2% maximum to 100 kHz.

Pulse Output

Output amplitude: >3 V positive (open circuit) TTL compatible.

Duty cycle: 13.5% to 16.5% of the total period.

Transition times: <25 ns.

External Frequency Control

VCO range: >10:1 on any frequency range.

Input requirement: with frequency dial set to 1.0, a linear ramp of 0.0 V to −10 V ±2 V will linearly increase frequency >10:1.

Input impedance: 10 kΩ ±10%.

General

Operating temperature: 0-55°C; specifications apply from +15°C to +35°C.

Storage temperature: −40°C to +75°C.

Power: 100/120/220/240 V −10%, +5% switchable: 48 Hz to 440 Hz; ≤12 VA.

Dimensions: height, 3½" (89 mm), width, 6¼" (160 mm), depth, 9¾" (248 mm).

Weight: net, 3-1/3 lbs (1,5 kg); shipping, 5½ lbs (2,5 kg).

Price: $249.

GENERAL INFORMATION

Frequency synthesizer equals stability translator

Hewlett-Packard frequency synthesizers translate the stable frequency of a precesion frequency standard to one of thousands or even billions of frequencies over a broad spectrum that extends from dc to 1300 MHz.

Direct and indirect synthesis

Hewlett-Packard builds two types of frequency synthesizers, "direct" and "indirect." Direct synthesis performs a series of arithmetic operations on the signal from the frequency standard to achieve the desired output frequency. In indirect synthesizers of the type built by Hewlett-Packard, several internal oscillators are phase-locked to signals derived from the frequency standard. The outputs of these phase-locked oscillators are then combined to form the desired output frequency.

Direct type synthesizers

The 5100B/5110B and the 5105A/5110B Synthesizers are made up of two completely solid-state units: the synthesizer proper, and the driver.

The driver contains a frequency source, a spectrum generator, and appropriate selective networks. The source is a high quality crystal oscillator housed in an oven. It is well protected from line voltage variations, and has an aging rate of less than three parts in 10^9 per day.

The driver provides a series of fixed frequencies between 3 and 39 MHz which are fed to the synthesizer unit. The 5110B Driver provides outputs (optional) to drive up to four synthesizers simultaneously. This feature effectively reduces the cost per synthesizer in multiple output systems.

The synthesizer unit contains harmonic generators and suitable mixers, dividers, and amplifiers to derive the desired output frequency as a function of the fixed frequencies. The front panel pushbuttons actuate a diode switching matrix.

All frequencies appearing at the inputs to this matrix are always present. This is the advantage of the direct synthesis method; it allows fast switching speeds.

High speed switching

The oscillogram of Figure 1, Page 334, shows the 20 microsecond or better speed which is typical of the Hewlett-Packard 5100B and 5105A Synthesizers when they change output frequency under electronic command. The upper waveform is synthesizer output; the lower is the externally applied switching voltage. Note the virtual absence of dead time and switching transients.

Reliability

Since their introduction in 1963, Hewlett-Packard 5100 Series Synthesizers have proven their high performance and reliability in many critical applications. Their continued use in deep space tracking systems, military satellite communication systems and radar applications attest to their performance and reliability. Actual operating field history has demonstrated a mean time between failure (MTBF) in excess of 10,000 hours for the synthesizer system.

Indirect type synthesizers frequency generation

The 3320A/B, 3330A/B and 8660A/B are made up of one or more phase-locked loops, locked to a reference crystal oscillator. Each phase-locked loop generates a variable output frequency which has the long term stability of the reference crystal oscillator.

The 3320A/B contains only one phase-locked loop since only three significant digits of frequency must be controlled (each PLL can generate three variable digits followed by several zeroes).

The 3330A/B and 8660A/B require several phase-locked loops since eight variable digits of frequency are generated. PLL's are used both to generate frequency digits and to sum digits.

Level control

The output of the frequency generation section is applied to the input of the level control circuits:

1. The 3320A and 3330A filter and amplify the output. A potentiometer provides 0 to +13 dBm (50Ω) output control.
2. The 3320B and 3330B use a unique True RMS output scheme to provide .05 dB flatness and .01 dB level resolution over a 100 dB output range.
3. The 8660A/B use several interchangeable plug-ins to provide output flexibility including a wide range attenuator with 1 dB resolution and AM/FM capability.

Digital sweep

The 3330A/B and 8660B are the most accurate sweepers ever built. Keyboard control of the built-in microprocessor gives all three instruments digital sweep (a point-by-point sweep with frequency synthesizer accuracy.) Phase continuity when switching is very good. This means that high Q devices can be swept quickly and accurately.

The 3330B also offers digital amplitude sweeps. Amplitude can be swept in increments as small as 0.01 dB to test level sensitive circuits like voltage-controlled oscillators and automatic gain control loops.

Communications applications

The high spectral purity of synthesizer output signals makes them ideal as local oscillators in receiver applications where frequency agility and/or narrow I.F. bandwidths are required of the receiver.

Precise level control in the 3320B and 3330B synthesizers removes the need for external leveling and attenuation. With 0.01 dB resolutions, even the most demanding applications in manufacturing and operating companies can be satisfied.

A surveilliance receiver system which monitors multiple data channels by rapidly switching between channels is an ideal area of application for one of the Hewlett-Packard frequency synthesizers. With its rapid, highly repeatable switching capability, a synthesizer will serve as the local oscillator in this type of receiver, providing the proper local oscillator frequency for each channel under surveillance. A similar application arises in radio sounding applications.

Radar applications

The 5100B/5110B is capable of switching between output frequencies in 0.01 Hz increments at a very fast rate; thus it is capable of making very good approximations of frequency versus time functions. This performance feature finds application in high performance "chirp" radar installations, which require an ultralinear sweep.

In doppler radar applications, the Hewlett-Packard frequency synthesizer supplies all the necessary requirements for precise velocity measurements. The excellent stability of the synthesizer makes it ideal as the basic signal source in the transmitter, which requires stability capable of staying within a receiver bandwidth only a few cycles wide in the microwave region. A frequency synthesizer also is well suited for use as the local oscillator in the doppler receiver, where the local oscillator must be capable of rapid change in order to keep the returning signal within the narrow receiver bandwidth.

NMR applications

Nuclear magnetic resonance spectroscopy methods are used to determine the qualitative and quantitative structure of molecules. In NMR, the strength of an applied dc magnetic field and the frequency of simultaneously applied rf field uniquely determine the spin-interaction of nuclei. In this application, the broad frequency range and precise 0.01 Hz increments of frequency are very valuable.

New synthesizer features

Manual or programmable AM/FM

Use the 86632A modulation section with the 8660A/B main frames to generate precise AM and FM signals. Built-in oscillators provide the modulation.

Precise level control

A new idea in synthesizers. 100 dB of level range, 0.05 dB flatness, and 0.01 dB resolution make the 3320B and 3330B unique as synthesizers. Precise level control eliminates the need for external leveling and level monitoring.

Digital sweep

Most accurate sweepers ever built. A built-in microprocessor allows the 3330A/B and 8660B to do digital sweeps with synthesizer accuracy.

Keyboard control

Combination of Hewlett-Packard instrument and calculator technology. No more twisting knobs with the 3330A/B and 8660B. Simply enter frequency, level, and sweep parameters through a calculator-like keyboard.

Flexible remote control

Hewlett-Packard has a new corporate interface and programming structure . . . the ASCII Buss. The 3320B, 3330A/B and 8660B all plug right into the ASCII Buss with a variety of controllers, card readers, calculators and computers . . . plus other new Hewlett-Packard instruments.

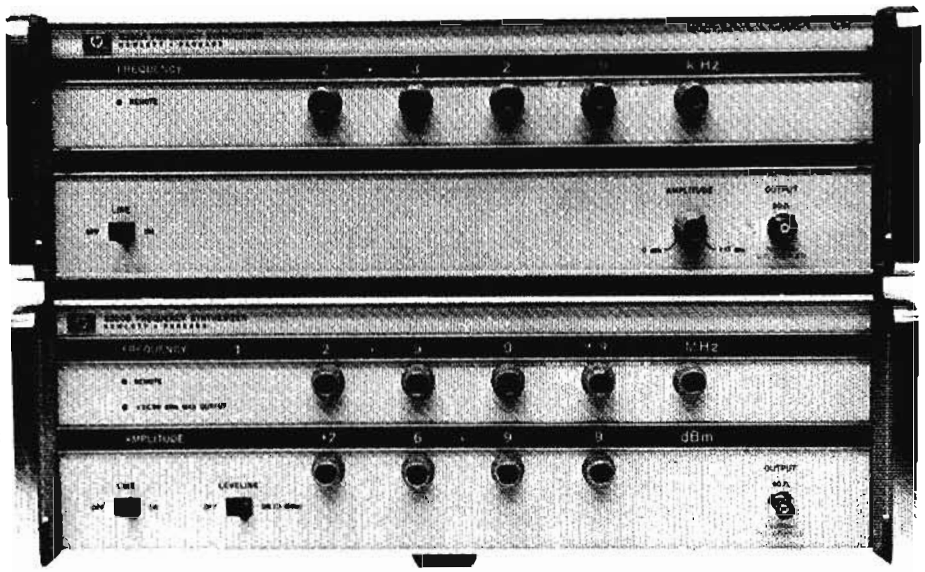
HP Model	Frequency Range	Frequency Resolution	Frequency Stability	Level Range dBm - 50Ω	Level Resolution	Remote Control	Other* Features
3320A (Pg. 328)	DC – 13 MHz 5 Ranges	0.01 Hz to 10 kHz (4 digits)	10^{-7} /day	0 to +13	¾ turn Vernier	Freq.	1
3320B (Pg. 329)	DC – 13 MHz 5 Ranges	0.01 Hz to 10 kHz (4 digits)	10^{-7} /day	−73 to +27	0.01 dB (4 digits)	Freq. and Ampl.	1
3330A (pg. 330)	DC – 13 MHz	0.1 Hz (9 digits)	10^{-8} /day	0 to +13	¾ turn vernier	Freq.	2, 5, 8
3330B (Pg. 331)	DC – 13 MHz	0.1 Hz (9 digits)	10^{-8} /day	−87 to +13	0.01 dB (4 digits)	Freq. and Ampl.	2, 5, 6, 8
5100B/5110B (Pg. 333)	DC to 50 MHz	0.01 Hz (10 digits)	3 x 10^{-9} /day	+13 fixed		Freq.	4
5105A/5110B (Pg. 333)	100 kHz - 500 MHz	0.1 Hz (10 digits)	3 x 10^{-9} /day	−6 to +6	¼ turn pot	Freq.	3, 4
8660A/86601A/ 86632A (Pg. 340)	10 kHz to 100 MHz	1 Hz (9 digits)	3 x 10^{-8} /day	−146 to +13	1 dB steps plus Vernier	Freq. and Ampl.	7, 8, 9
8660A/86602A/ 86632A (Pg. 340)	10 kHz to 100 MHz	1 Hz (9 digits)	3 x 10^{-8} /day	−146 to +13	1 dB steps plus Vernier	Freq. and Ampl.	7, 8, 9
8660B/86601A/ 86632A (Pg. 340)	1 MHz to 1300 MHz	1 Hz (10 digits)	3 x 10^{-8} /day	−146 to +13	1 dB steps plus Vernier	Freq. and Ampl.	5, 7, 8, 9
8660B/8660A/ 86632A (Pg. 340)	1 MHz to 1300 MHz	1 Hz (10 digits)	3 x 10^{-8} /day	−146 to +13	1 dB steps plus Vernier	Freq. and Ampl.	5, 7, 8, 9

*Other features

1 10^{-8} /day freq. stability optional
2 10^{-9} /day freq. stability optional
3 external phase modulation
4 internal search oscillator
5 digital freq. sweep
6 digital ampl. sweep
7 internal AM/FM
8 external AM
9 3 x 10^{-9} /day stability opt. 001

FREQUENCY SYNTHESIZER
.01 Hz to 13 MHz frequency standard/test osc.
Models 3320A, 3320B

3320A



3320B

Description

The 3320A/B Frequency Synthesizer has the frequency accuracy, stability, and resolution demanded by many of today's exacting applications. The ease and flexibility of adding greater stability means the 3320A/B can be tailored to your needs as they emerge. Spectral purity and low signal-to-phase noise complement the frequency qualities of the 3320A/B.

The 3320B is more than a synthesizer. It offers precise level control, superior frequency response, low harmonic distortion and high power output.

Two choices of digital remote control afford great flexibility for today's system applications. High precision in both frequency and amplitude means that expensive system monitoring is unnecessary.

Frequency

The 3320A/B Frequency Synthesizer has a broad frequency range of 0.01 Hz to 13 MHz in seven frequency ranges.

Three digits plus a ten-turn two-digit continuous vernier, plus 30% overrange capability, gives the 3320A/B one part in 10^6 frequency resolution across its total frequency range.

Amplitude

The 3320A has a maximum one volt rms into 50 ohms output (+13 dBm) with a continuous +13 dBm to 0 dBm amplitude vernier

The 3320B features a four-digit leveling loop with a 0.01 dB level resolution of a calibrated output from +26.99 dBm to −69.99 dBm (−73.00 dBm under remote control).

Frequency response of ±0.05 dB over the range of 10 Hz to 13 MHz, and level accuracy of ±0.05 dBm absolute at 10 kHz, complement the level capability of the 3320B.

Programmability/Remote Control

The 3320A/B is a programmable signal source. Digital remote control capability may be purchased installed in the instrument, or may be added later if the need arises.

The 3320A with its Option 003 allows parallel BCD remote control of frequency only. The first digit of the frequency vernier and the frequency range may be controlled digitally, as well as the main frequency digits.

The 3320B has two remote control options. Both options allow full control of all functions except the last vernier digit and the line switch. Option 004 is parallel BCD remote control capability. Option 007 is a unique bit-parallel/word-serial ASCII programming option. This option is advantageous where several 3320B's need to be controlled, since only one programming device is needed. The ASCII programming option has eight input lines, thus allowing direct interface to the HP 3260A Marked Card Programmer, photo reader, or any other eight-bit controller. This buss line programming means a saving of computer interface slots and a simplification of software.

Specifications, 3320A/B

Frequency range: 0.01 Hz to 13 MHz in 7 ranges.

Frequency ranges: 10 MHz, 1000 kHz, 100 kHz, 10 kHz, 1000 Hz; 100 Hz and 10 Hz (optional). 30% overrange on all ranges.

Frequency resolution:

Range	Vernier Out (local or remote)	Vernier In (local)	Vernier In (remote)
10 MHz	10 kHz	10 Hz	1 kHz
1000 kHz	1 kHz	1 Hz	100 Hz
100 kHz	100 Hz	0.1 Hz	10 Hz
10 kHz	10 Hz	0.01 Hz	1 Hz
1000 Hz	1 Hz	1 mHz	0.1 Hz
100 Hz	0.1 Hz	0.1 mHz	0.01 Hz
10 Hz	0.01 Hz	0.01 mHz	0.001 Hz

Frequency accuracy

Vernier out: ±0.001% of setting for 6 mo, 0°C to 55°C.

Vernier in: ±0.01% of range for 6 mo, 0°C to 55°C.

Frequency stability

Long term: ±10 parts in 10^6 of setting per year (vernier out) with ambient temperature reference. Optional high stability crystal reference oven available (Option 002).

Signal-to-phase noise (integrated): >40 dB down in 30 kHz band, excluding ±1 Hz, centered on carrier. 10 MHz range, vernier out. Improves on lower frequency ranges.

Harmonic distortion: with output frequencies >0.1% of range at full output amplitude, any harmonically related signal will be less than the following levels.

−60 dB with output from 5 Hz to 100 kHz.
−50 dB with output from 100 kHz to 1 MHz.
−40 dB with output from 1 MHz to 13 MHz.

Spurious: >60 dB down.

Internal frequency standard: 20 MHz crystal.

Phase locking: the 3320A/B may be phase locked with a 200 mV to 2 V rms signal that is any subharmonic of 20 MHz.

Rear panel output: front or rear panel output is standard.

Auxiliary outputs

Tracking outputs: 20 MHz to 33 MHz offset signal. >100 mV rms/50Ω.

1 MHz reference output: 220 mV rms/50Ω (> dBm/50Ω).

Low level output: same frequency as main output but remains between 50 mV rms and 158 mV rms (into 50Ω) depending on main output level setting.

3320A Amplitude Section

Amplitude: maximum 1 v rms ±10% into 50Ω.

Amplitude range: 0 dBm to +13 dBm range through ¾ turn front panel control (not programmable).

Frequency response: ±2 dB over total range.

Output impedance: 50Ω (75Ω, Option 001).

3320B Amplitude Section

Amplitude range: +26.99 dBm (½ watt) to −69.99 dBm (−73.00 dBm under remote control) into 50Ω. (+26.99 dBm = 5 V rms into 50Ω).

Amplitude resolution: 0.01 dB.

Frequency response (10 kHz reference):

dc – 10 Hz	10 Hz – 13 MHz	Level
±0.5 dB	±0.05 dB	+26.99 dBm to −3.00 dBm
±0.5 dB	±0.1 dB	−3.00 dBm to −23.00 dBm
±0.5 dB	±0.2 dB	−23.00 dBm to −53.00 dBm
±0.5 dB	±0.4 dB	−53.00 dBm to −73.00 dBm

Amplitude accuracy (absolute): +26.99 dBm, ±0.05 dB at 10 kHz and (20°C to 30°C).

Output impedance: 50Ω (75Ω, Option 001).

Options

Option 001 (3320A/B) 75 ohm

Amplitude range (3320B only): +24.99 dBm to −69.99 dBm (−75.00 dBm under remote control) into 75Ω.

Option 002 (3320A/B) crystal oven*

5 MHz crystal in temperature stabilized oven.

Long term stability: ±1 part in 10^8/day; ±1 part in 10^7/mo.

Frequency accuracy: ±1 part in 10^7 of setting per mo. For field installation order accessory kit HP 11237A.

Option 003 (3320A only) BCD remote control*

Allows digital remote control of frequency only on 3320A. The most significant digit of the vernier may be programmed, thus giving four digits, plus 30% overrange, control of frequency in seven ranges (two are optional).

Frequency switching and settling time: ±0.1% or range, 15 ms; ±0.001% of range, 60 ms.

For field installation order accessory kit HP 11238A.

Option 004 (3320B only) BCD remote control*

Allows digital remote control of frequency and amplitude. **Four digits of frequency, overrange, frequency range, Vernier In/Out, four digits of amplitude, and leveling loop response times are all controlled digitally.

Frequency switching and settling time: ±0.01% of range, 15 ms; ±0.001% of range, 60 ms.

Amplitude switching and setting time: <1.5 s to rated accuracy.

Option 007* (3320B only) ASCII remote control

Allows bit-parallel word-serial remote control of all functions. **A 3320B with this option will recognize an address and then accept instructions in a serial fashion. Instructions are a seven-bit parallel ASCII code. Due to the addressing feature, up to ten 3320B's (with this option) may be programmed from one programmer. The HP 3260A Marked Card Programmer may be used as a programmer for this option.

This option requires eight digital input lines for full control. **Seven of the eight are programming input lines and one is a data command line.

Full digital isolation is standard with this option.

Logic Level Requirements for all Digital Remote Control Options.

State	Requirements
"Low" (logical "1")	0 V to 0.4 V (5 mA max.) or contact closure to ground through <80 ohms.
"High" (logical "0")	+2.4 V to +5 V or removal of contact closure to ground.

Option 006 (3320A/B) 100 Hz, 10 Hz Ranges*

Adds two lower frequency range, 100.0 Hz and 10.00 Hz, yielding greater resolution for low frequency outputs (see resolution section of specifications). These two ranges are fully programmable if digital remote options are installed.

For field installation, order accessory kit HP 11240A.

General 3320A/B

Operating temperature: 0°C to 55°C.

Storage temperature: −40°C to +70°C.

Power requirements: 115 V or 230 V ±10%, 48 Hz to 63 Hz, 110 VA max, (400 Hz operation on special basis).

Weight

3320A: 32 lbs (14,4 kg); shipping, 47 lbs (21,3 kg).

3320B: 34 lbs (15,4 kg); shipping, 49 lbs (22,2 kg).

Dimensions: 16¾" wide, 19⅜" deep, 5-7/32" high (425 x 491,5 x 132,6 mm).

Accessories furnished: rack mounting kit.

Prices: HP 3320A, $1900: Option 001, 75Ω output, N.C.; Option 002, crystal oven, add $290; Option 003, BCD remote control, add $300; Option 006, 100 Hz/10 Hz ranges, add $200.

HP 3320B, $2550: Option 001 75Ω output, Option 002, crystal oven, add $290; Option 004, BCD remote control, add $400; Option 006, 100 Hz/10 Hz ranges, add $200; Option 007, ASCII remote control, add $595.

Kit for interfacing to Hewlett-Packard 2100 Series computers. HP 11232A for interfacing 3320B Option 007.

Useful accessories

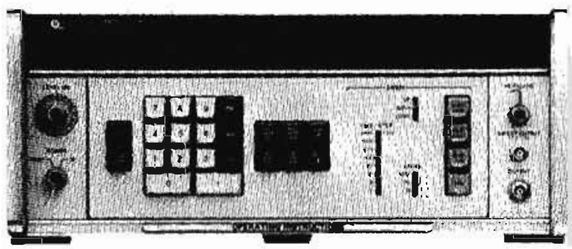
HP 11048C, 50Ω feedthrough, $15; HP 11094B, 75Ω feedthrough, $15; HP 3260A Marked Card Programmer allows the 3320B with ASCII remote to be easily programmed by a punched or marked card.

*Field Installable
**Except last vernier digit and line switch.

AUTOMATIC SYNTHESIZER

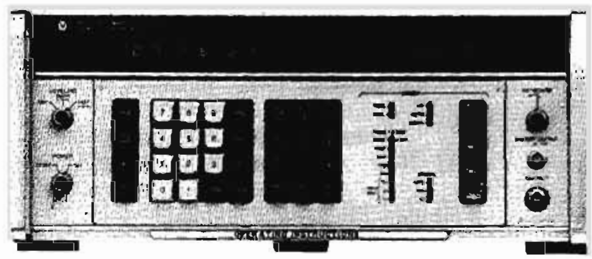
Digital sweeping of frequency and amplitude

Models 3330A and 3330B



3330A

NEW



3330B

NEW

Description

Two new frequency synthesizers, the 3330A and 3330B, have a stability of ±1 x 10^{-8} per day, −50 dB signal-to-phase noise, with a constant resolution of 0.1 Hz up to 13 MHz. These new signal sources have read-only-memories (ROM's) built in for control of all instrument operations. Four-digit amplitude control to a resolution of 0.01 dB over a 100 dB range is standard on the Model 3330B. The 3330A has a manual control for amplitude, and output is leveled to ±0.5 dB. Both instruments are programmable except for amplitude of the Model 3330A.

Operation of both instruments is controlled from an easy-to-use keyboard. Solid-state displays show frequency and amplitude on the Model 3330B, and frequency only on the Model 3330A. Nine digits of frequency are displayed on both instruments, and four digits of amplitude on the Model 3330B.

Spectral purity not normally associated with frequency synthesizers, is a feature of both units. Spurious is >70 dB below the carrier and harmonics are >60 dB to 40 dB below the carrier, depending upon the frequency setting. As sweepers, the instruments use digital sweeping for linearity. Either single or continuous sweeps may be set up. Parameters such as center frequency, frequency step, time per step, and the number of steps go into the memory, then are executed by pressing a single button. The ROM operates the sweep as set up until told to stop. Many of the sweep parameters can be changed while the instrument is sweeping. The Model 3330B sweeps amplitude in steps as small as 0.01 dB. The amplitude can be stepped at the end of each frequency sweep cycle to produce a family of curves.

Both instruments are fully programmable. Both models can be amplitude modulated using an external signal of up to 100 kHz.

Specifications, 3330A/B

Frequency range: 0.1 Hz to 13,000,999.9 Hz.

Frequency resolution: 0.1 Hz (8 digits + overrange).

Frequency stability

Long term

±1 x 10^{-8} of frequency per day.

±1 x 10^{-7} of frequency per month.

Temperature

±1 x 10^{-8} of frequency at 25°C ±10°C.

±1 x 10^{-7} of frequency at 0°C to 55°C.

Largest digit changed	0.1 Hz or 1 Hz	10 Hz or 100 Hz	1 kHz or 10 kHz	100 kHz, 1 MHz or 10 MHz
Switching and Settling Time	<1 ms to within 500 μHz	<1 ms to within .05 Hz	<1 ms to within 5 Hz. <50 ms to within 0.01 Hz	<1 ms to within 500 Hz; <50 ms to within 1 Hz

FREQUENCY STEP, NUMBER OF STEPS, TIME PER STEP, and SWEEP DIRECTION.

Sweep width: the product of STEP SIZE and NUMBER OF STEPS.

Step size: continuously adjustable in 0.1 Hz increments.

Step accuracy: $\pm 1 \times 10^{-8}$ per day for standard reference crystal.

Number of steps: 10, 100, or 1000.

Time per step: 1 ms, 3 ms, 10 ms, 30 ms, 100 ms, 300 ms, 1000 ms, and 3000 ms.

Direction of sweep: up, both, down.

Single sweep: initiated by momentary pushbutton.

Continuous sweep: initiated by momentary pushbutton.

Manual sweep: accomplished by holding down the FREQ↑ or FREQ↓ keys. Display will follow output.

Sweep output: stepped dc voltage proportional to sweep position, 0 to +10 V.

Accuracy: ±0.2% of full scale.

Linearity: ±0.1% of full scale.

Digital outputs

Step count: 0 to 1000 count on 12 BCD (1-2-4-8) lines to indicate sweep position.

Sweep status: line to indicate when instrument is sweeping.

Step ready: indicates instrument has spent the selected time per step and is ready to go to the next step.

Sweep modification (continuous): during a continuous sweep, the STEP SIZE, CENTER FREQUENCY, SWEEP DIRECTION, and TIME PER STEP may be changed without stopping the sweep.

Center frequency modification: accomplished by pressing FREQ↑ or FREQ↓.

Frequency step: to widen or narrow the sweep width, the frequency step size may be expanded or contracted by factors of 2 or 10. The keys labeled FREQ STEP ×2, FREQ STEP ÷2, FREQ STEP ×10 and FREQ STEP ÷10 may be pressed.

Sweep modification (single): during a single sweep, the TIME PER STEP and DIRECTION SWEEP may be changed without stopping the sweep.

3330A amplitude section

Amplitude:

maximum 2 V rms ±10% open circuit.

maximum 1 V rms ±10% into 50Ω.

Amplitude range: −0 dBm to +13 dBm range through ¾ turn front panel control (not programmable).

Frequency response (10 kHz reference): ±0.5 dB across total range.

Output impedance: 50Ω (75Ω Option 001).

Amplitude modulation: requires external modulation source. Rear panel BNC.

Modulating signal: dc to 100 kHz.

Modulation depth: 0.95 V rms modulating signal for 95% modulation depth. (0.01 V rms/1% depth.)

3330B amplitude section

Amplitude:

maximum 2.1 V rms into open circuit.

maximum 1.05 V rms into 50Ω.

Amplitude range: +13.44 dBm to −86.55 dBm into 50Ω.

Amplitude resolution: 0.01 dB.

Output impedance: 50Ω (75Ω Option 001).

Display: four digit readout in dBm with reference to 50Ω.

Leveled frequency response (10 kHz reference) 10 Hz-13 MHz.*

+13.44 dBm to −16.55 dBm: ±0.05 dB

−16.55 dBm to −36.55 dBm: ±0.1 dB

−36.55 dBm to −66.55 dBm: ±0.2 dB

−66.65 dBm to −86.55 dBm: ±0.4 dB

*Add ±0.5 dB for leveling off.

Amplitude attenuator accuracy: ±0.02 dB/10 dB step (at 10 kHz) of attenuation down from maximum output.

Amplitude accuracy (absolute): ±0.05 dB at 10 kHz and +13.44 dBm (15°C ±5°C). (For absolute accuracy at other frequencies and amplitudes, add 0.05 dB to the leveled frequency response specification, plus the attenuator accuracy specification.)

Amplitude modulation: requires external modulation source. Rear panel BNC. ALC switch must be in SLOW position.

Modulating signal: 100 Hz to 100 kHz.

Modulation depth: 0.95 V rms modulating signal for 95% modulation depth.

Digital sweeping of amplitude (3330B only): accomplished by entering and setting the CENTER AMPLITUDE, an AMPLITUDE STEP, NUMBER OF STEPS, TIME PER STEP and SWEEP DIRECTION.

Type: linear and symmetrical about the center amplitude.

Sweep width: product of the STEP SIZE and NUMBER OF STEPS.

Step size: 0.01 dB to 99.99 dB in 0.01 dB increments.

Number of steps: 10, 100, or 1000.

Time per step: 30 ms, 100 ms, 300 ms, 1000 ms, 3000 ms.

Direction of sweep: up, both, down.

Single sweep: momentary pushbutton. Display follows output.

Continuous sweep: momentary pushbutton. Display of center amplitude or step.

Manual sweep: accomplished by holding down the AMPL↑ or AMPL↓ keys. Display will follow output.

Sweep output, digital outputs, sweep modification (continuous), sweep modification (single), all the same as with frequency sweep.

Digital remote control

The 3330A and 3330B are programmable on a standard basis. The 3330B allows full programming of frequency, amplitude, sweeping. The 3330A has full programming of frequency and all frequency sweeping controls, but not amplitude.

Each key, slideswitch position, and control has a seven-bit parallel ASCII code assigned to it. Programming is accomplished by sending the 3330A/B a series of seven-bit codes (instructions). Before the instrument will accept instructions, it must be addressed. This is done by preceeding the first instructions with the ASCII code for the instrument being addressed. The address of a 3330A/B is set at Octal "044" by the manufacturer but may be easily changed by the user.

The addressing capability of the 3330A/B allows up to 15 units to be connected in parallel on the ASCII buss. Up to 63 different addresses are available.

The HP 3260A Marked Card Programmer may be used as a programmer for one or more 3330A/B's.

Timing: maximum of 310 μs per digit.

Maximum of 1 ms to enter and initiate program control codes.

Maximum of 2.5 ms to enter and initiate sweep.

Input control lines: 7 "Program Data" lines.
1 "MRE"*
1 "Data Strobe" line
1 "Remote Enable" line
1 "Step Inhibit" line (use not required)

Output control lines: 1 "Ready for Data"
1 "Data Accepted"
14 "Sweep Parameter" lines
(use not required)

Isolation: the input and output control lines on the standard 3330A/B do not have isolated grounds with respect to output signal ground. For isolation of these digital grounds, order Option 004.

*Multiple Response Enable.

Logic level requirements:

State	Requirements
"Low" (logical "1")	0 V to 0.4 V (5 mA max) or contact closure to ground through <80 ohms.
"High" (logical "0")	+2.4 V to +5 V or removal of contact to ground.

Options

Option 001, 75 Ohms - 1 V RMS
Attenuation and output referenced to 75Ω.
Amplitude range
3330A: +11 dBm to −2 dBm.
3330B: +11.25 dBm to −88.74 dBm. (Factory installation only.)

Option 002, High Stability Crystal Oven
Frequency stability
Long term:
±1 x 10^{-9} per day.
±2 x 10^{-8} per month.
Temperature:
±1 x 10^{-9} total frequency at 25°C, ±10°C.
±1 x 10^{-8} total of frequency at 25°C, 0°C to +55°C.
Frequency adjustments: same as standard instrument.

Option 003, Deletion of Crystal Oven
20 MHz ambient temperature crystal reference oscillator.
Frequency stability: ±10 parts in 10^6/yr.
Frequency adjustments: rear panel 1 turn pot or rear panel voltage control input for 30 x 10^{-6} maximum control.

Option 004, Isolated Digital Input. (Factory installation only.)
With this option, the digital input lines are electrically isolated from the signal ground.
DC isolation: ±250 V.
AC isolation: >30 dB, 0 to 1 MHz.

Option 005, 5 V RMS - 50 Ohm Output
This option gives the 3330A/B a ½ watt output.
Amplitude range
3330A: 27 dBm to 14 dBm into 50 ohms.
3330B: +26.99 dBm to −73 dBm into 50 ohms.
All other specifications remain unchanged.

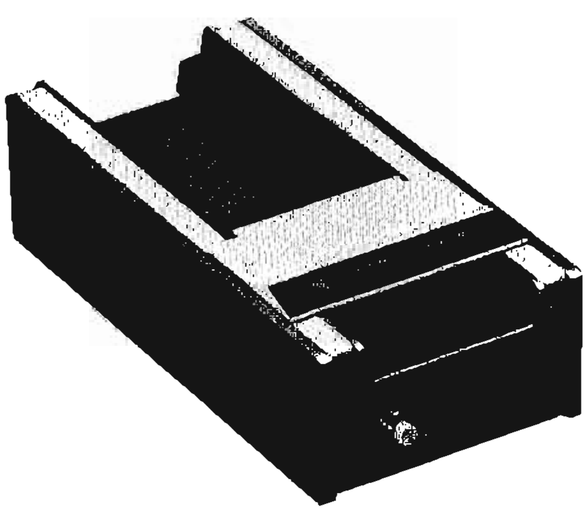
General

Operating temperature: 0°C to +55°C.
Storage temperature: −40°C to +70°C.
Turn on time
Application of power to "On": <20 min to within ±1 x 10^{-7} of the final frequency.
"Standby" to "On": <15 s to full specifications.
Power requirements: 115 V or 230 V ±10%, 48 Hz to 63 Hz, (400 Hz line frequency operation on special basis), <20 W standby, <200 W on.
Weight
3330A: 49 lbs (22,1 kg); shipping 58 lbs (26,4 kg).
3330B: 53 lbs (22,6 kg); shipping 63 lbs (26,8 kg).
Dimensions: 16¾" wide x 7" high x 21½" deep (426 x 178 x 547 mm).
Price:
3330A, $5100, 3330B, $6000.
Option 001, 75Ω - 1 V Output, no charge.
Option 002, Crystal Oven, add $500.
Option 003, Deletion of Oven, less $200.
Option 004, Isolated ASCII, add $225.
Option 005, 5 V - 50Ω Output, add $250.

MARKED CARD PROGRAMMER

Reads marked and punched cards

Model 3260A



3260A

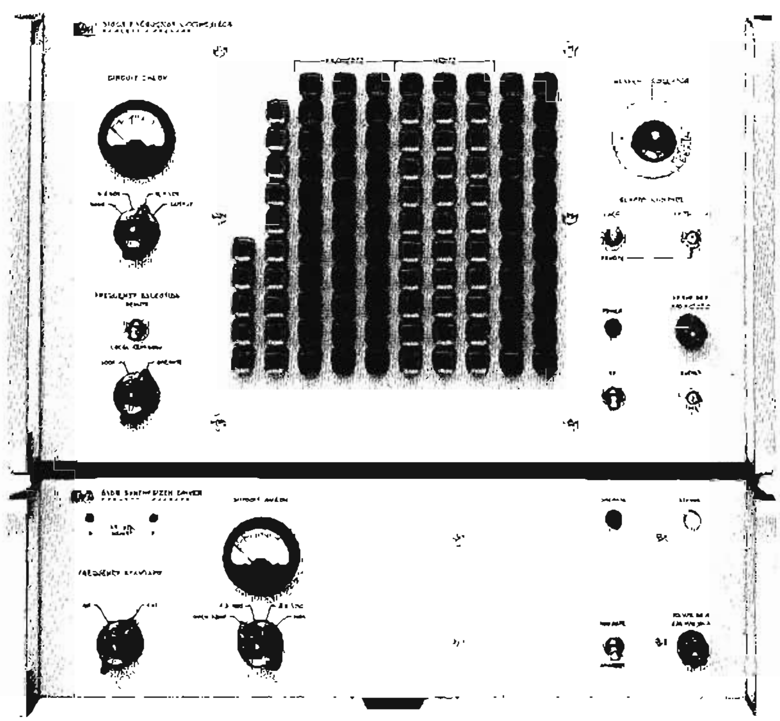
Description

The Hewlett-Packard Model 3260A is an eight channel optical mark sense card reader. The HP 3260A Marked Card Programmer detects pencil marks on hand-fed cards and gives a voltage output corresponding to the presence of marks in the eight columns. Punched holes are sensed the same as pencil marks. The TTL logic level output is "1" state low. The 3260A has its own internal power supply and card drive motor for maximum versatility. Cards are stacked in the output tray from the bottom so that the original card order is always retained.

General

Weight: net, 8 lb (3,7 kg); shipping, 11 lb (5 kg).
Power: 120 V or 240 V +5% −10%, 48 Hz to 440 Hz, <8 VA when idle, <9 VA when reading a card.
Dimensions: 5-1/3" wide, 3½" high, 11¼" deep (134,5 x 88,9 x 285,8 mm).
Temperature: operating range, 0° - 55°C.
Cable: 5 ft detachable cable supplied with Hewlett-Packard ASCII bus connector. Connector is in stackable housing for parallel connection to multiple devices.
Cards
Furnished: 100 program cards (HP Part Number 9320-2886). Dimensions are 7⅜" x 3¼" (187,2 x 82,6 mm).
Available: package of 2000, $15; package of 10,000, $60. Output tray extends for use with 11 inch cards.
Price: HP 3260A, $750.

FREQUENCY SYNTHESIZERS
DC to 50 MHz or 100 kHz to 500 MHz
Models 5100B/5110B and 5105A/5110B



DC to 50 MHz in 0.01 Hz increments
Model 5100B/5110B

Advantages:

- Frequencies from dc to 500 MHz
- Remote programming
- Switching speed typically 20 μs
- Proven reliability

Applications:

- Automatic testing of frequency-sensitivity devices
- Communications systems
- Doppler radar

The Models 5105A/5110B and 5100B/5110B together provide complete frequency coverage from dc to 500 MHz. The instruments both use direct synthesis to achieve their very fast switching speeds and high spectral purity. This technique translates the stability and spectral purity of a reference source to the selected output and in addition provides a fail-safe output. A precision high stability 1 MHz quartz oscillator is provided, or an external 1 MHz or 5 MHz standard may be used. Both units provide pushbutton or remote frequency selection and include a selectable search capability. The 5105A has 0.1 Hz steps from 100 kHz to 500 MHz in addition to a variable output level and phase modulation. The 5100B provides 0.01 Hz steps from dc to 50 MHz (dc to 100 kHz from separate connector). The 5110B Synthesizer Driver supplies 22 fixed frequencies required to input to the 5105A or 5100B. Both units or any combination of them up to four may be driven by the 5110B.

Continuous tuning, sweep, FM

For both units a search oscillator provides continuously variable frequency selection over the range of any one column except the left-hand two. Operation of a front-panel control or application of an external dc voltage tunes the search oscillator over the complete frequency range of the selected digit (column). One of the advantages afforded by continuous control is the easy identification of an unknown frequency by beating it against the synthesizer output.

The search oscillator can be frequency modulated from an external source (sinewave) at a maximum rate of 1 kHz while retaining the voltage control calibration.

Remote operation

The 5105A/5110B and 5100B/5110B Synthesizers provide great control flexibility of a precision frequency source over a range greater than ever before available. Any frequency or search oscillator position available from the keyboard can be remotely selected and can be rapidly switched: in 20 μs, typically.

Rear panel connectors on the 5105A/5100B provide pins corresponding to each front panel pushbutton, a ground connection, and a −12.6 volt line for use in remote programming. A combination of remote and local programming may be used, if so desired. For parallel BCD commands use HP 2759B Programmer.

No actual contact closure, such as a relay, is required. The —12.6 volts dc may be applied to the selected pin by electronic means.

Fast switching

The remarkably fast switching speed, valuable for such tasks as automatic digital frequency tracking, is one of the significant advantages of the direct synthesis method.

Figure 1 shows (upper trace) the 5105A/5110B output frequency switched between 399.8 MHz and 400.2 MHz with 400 MHz subtracted to display switching in greater detail. The sweep is 25 μs/cm. The lower trace is that of the switching waveform applied to the synthesizer. The 5100B/5110B displays similar performance up to 50 MHz.

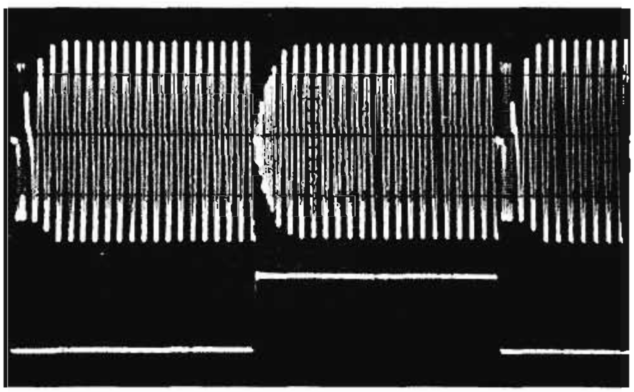


Figure 1. Synthesizer switching speed (25 μs/cm).

Low noise performance

To achieve the excellent low-noise output specified for the Hewlett-Packard synthesizers over the full range requires the utmost care in design to identify and minimize noise sources followed by extensive testing at each stage of manufacture.

Figure 2 shows typical phase noise distribution for both synthesizers. The ratio of output signal to single-sideband phase noise (in a 1 Hz bandwidth) is plotted against frequency of offset from the signal.

The noise performance reflected in this plot is very good for instruments as complex and versatile as the 5105A and 5100B. It also demonstrates their suitability for applications where spectrum requirements are critical.

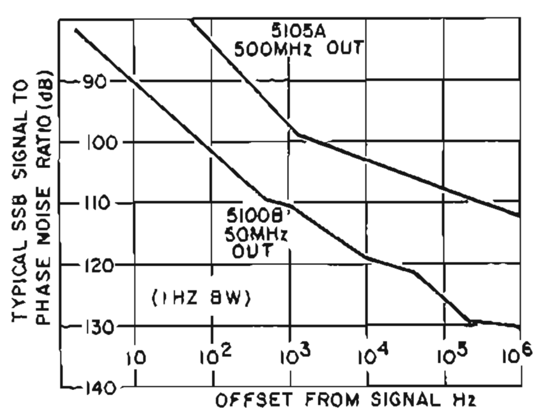


Figure 2. Composite phase noise plot for Hewlett-Packard synthesizers.

Spectral purity and stability

Particular care has been exercised in the design of the Hewlett-Packard synthesizers to insure a very clean output signal is provided over the entire frequency range of the instruments. A high order of spectral purity is essential for accurate doppler measurements, microwave spectroscopy, narrow band telemetry, communications and similar applications. The careful design and modular construction of the synthesizers make it possible to obtain output signals with spurious content at least 90 dB below the selected output in the case of the 5100B. The 5105A spurious signals are at least 70 dB below its output over the entire 500 MHz range.

Many applications require that a signal be multiplied into the microwave region. If the frequency multiplying device is broadband, the ratio of total sideband power to signal power increases as the square of the multiplying factor. Since the total power in a frequency modulated wave is constant, the increased sideband power must come from the carrier. The spectrum of the signal begins to "spread" since the increased sideband amplitude causes the intermoduation between sidebands to become appreciable. It is desirable, then, that the original signal have the highest possible signal to phase noise ratio.

The specified values in the table on the next page for rms Fractional Frequency Deviation at various averaging times and at various output frequencies represent the standard deviation of the short term frequency instability due to random noise. For example, the value given for one-second averaging at an output of 500 MHz is 1×10^{-11}. This corresponds to a standard frequency deviation of 0.0050 Hz. In other words, 68.3% of all observed frequency variations for measurement times of one second will differ from the carrier by less than plus or minus that amount. 99.7% of all frequency variations will differ from the carrier by less than ±0.0150 Hz.

Modular construction

Modular construction has been used throughout the synthesizers and driver. The modular concept enables the system to meet stringent demands regarding spurious signals since the isolation that it affords minimizes spurious coupling. It also enhances serviceability and reliability. Careful design and quality control insure that all modules are interchangeable from one instrument to another.

Synthesizer driver, 5110B

The HP 5110B Synthesizer Driver supplies the HP 5100B and 5105A Synthesizers with 22 fixed, spectrally pure signals derived from a 1 MHz precision quartz oscillator.

The 1 MHz quartz oscillator which is the source for all output frequencies of the synthesizer driver is stable to 3 parts in 10^9 per 24 hours. To help maintain this excellent crystal stability, oven circuits are energized any time the instrument is connected to the power line. A circuit check meter allows verification of correct oven operation.

Where special requirements make it necessary that synthesized frequencies be derived from an external frequency standard, a rear panel connector on the 5110B accepts a 1 MHz or 5 MHz signal. The output spectral purity is partially dependent on the purity of the remote frequency standard.

Specifications

Specifications for the 5105A and 5100B Synthesizers and 5110B Synthesizer Driver are given on the following page.

Specifications
5100B/5110B and 5105A/5110B Synthesizers

Specifications	5105A/5110B	5100B/5110B
Output frequency	100 kHz to 500 MHz	dc to 50 MHz
Digital frequency selection	0.1 Hz through 100 MHz per step. Selection by front panel pushbutton or by remote switch closure. Any change in frequency may be accomplished in 20 μs typically.	0.01 Hz through 10 MHz per step. Selection by front panel pushbutton or by remote switch closure. Any change in frequency may be accomplished in 20 μs typically.
Output voltage	Fixed: 0 dBm ± 1 dBm into a 50 ohm resistive load. Variable: −6 dBm to +6 dBm into a 50 ohm resistive load.	1 volt rms ± 1 dB from 100 kHz to 50 MHz. 1 volt rms +2 dB, −4 dB from 50 Hz to 100 kHz, into a 50 ohm resistive load. Nominal source impedance is 50 ohms. 15 mV rms minimum open circuit dc to 100 kHz, at separate rear connector, source impedance of 10 K ohms with shunt capacitance 70 pF.
Search oscillator	Provides continuous variable frequency selection with a selectable incremental range of 1.0 Hz through 10 MHz. Manual or external voltage (−1 to −11 volts) control with linearity of ±5%. The search oscillator may be externally swept up to a 1 kHz sinewave rate.	Provides continuously variable frequency selection with an incremental range of 1.0Hz through 1 MHz. Manual or external voltage (−1 to −11 volts) control with linearity of ±5%. The search oscillator may be externally swept up to a 1 kHz sinewave rate.
Phase modulation	(rear panel input) ±3 radians maximum deviation; dc to 1 MHz rate.	
Signal-to-phase noise ratio*	Measured in a 30 kHz band centered on the signal (excluding a 1 Hz band centered on the signal) is greater than: (see table below)	Greater than 54 dB in a 30 kHz band centered on the signal (excluding a 1 Hz band centered on the signal).
Signal-to-AM noise ratio	(Above 100 kHz): Greater than 74 dB in a 30 kHz band.	
RMS fractional frequency deviation (with a 30 kHz noise bandwidth) using 5110B internal oscillator*	(see table below)	
Spurious signals	Non-harmonically related signals are at least 70 dB below the selected frequency	Non-harmonically related signals are at least 90 dB below the selected frequency
Harmonic signals	*25 dB below the selected frequency, (applicable to fixed output when terminated in 50 ohms).*	*30 dB below the selected frequency (when terminated in 50 ohms).*
Dimensions	16¾″ wide, 16⅜″ deep, 15-11/16″ high (425 x 416 x 398 mm), incl. 5110B	
Price	model 5105A, $11,000; model 5110B, $4500	model 5100B, $8750; model 5110B, $4500

Signal-to-phase noise ratio* (5105A/5110B):

Output frequency – MHz	1	50	100	500
Ratio – dB	48	48	48	40

RMS fractional frequency deviation (with a 30 kHz noise bandwidth) using 5110B internal oscillator*:

Averaging time	Output Frequency (5105A/5110B)				Output Frequency (5100B/5110B)			
	1 MHz	50 MHz	100 MHz	500 MHz	1 MHz	5 MHz	10 MHz	50 MHz
10 ms	1×10^{-7}	2×10^{-9}	1×10^{-9}	6×10^{-10}	3×10^{-8}	6×10^{-9}	3×10^{-9}	6×10^{-10}
1 s	2×10^{-8}	4×10^{-11}	2×10^{-11}	1×10^{-11}	3×10^{-10}	6×10^{-11}	3×10^{-11}	1×10^{-11}

* With the 5110B Driver internal frequency standard. When the 5110B Driver utilizes an external frequency standard, this will affect the stability and spectral purity of the output. Performance data stated above are based on the excellent internal frequency standard in the 5110B.

5110B Internal 1 MHz Quartz Oscillator

Aging rate: less than 3 parts in 10^9 per 24 hours.

Stability: as a function of ambient temperature: $\pm 2 \times 10^{-10}$ per °C from 0°C to +55°C. As a function of line voltage $\pm 5 \times 10^{-11}$ for a ±10% change in line voltage (rated at 115 or 230 volts rms line voltage).

Output, buffered: available at rear panel (1 V ±1.5 dB into 50Ω resistive load).

Phase-locking capability: a voltage control feature allows 5 parts in 10^8 frequency control for −5 to +5 volts applied externally to the 5110B.

External frequency standard input requirements: 1 MHz or 5 MHz, 0.2 V rms minimum, 5 V maximum across 500 ohms.

General (5105A/5110B and 5100B/5110B)

Operating temperature range: 0 to +55°C.

Interference: complies with MIL-I-26600, Class 1 and 3, MIL-I-6181D.**

Susceptibility: complies with MIL-I-26600, Class 1 and 3, MIL-I-6181D.

Power: 115 or 230 V ±10%, 50 to 400 cycles, 35 W each synthesizer and driver (separate power supplies).

Optional features: the synthesizer drivers are capable of driving up to four frequency synthesizers:
Option 002, outputs for driving two synthesizers, $125; Option 003, for three, $235; Option 004, for four, $345.
Any unused outputs must be terminated in 50Ω BNC terminations, 10510A.

Note: small phase jumps may be experienced in additional synthesizer when first is switched in frequency.

Weight: 5105A and 5100B, net 85 lbs (38 kg); shipping, 96 lbs (42 kg) each. 5110B, net, 56 lbs (26 kg); shipping 62 lbs (28 kg).

Accessories furnished: 5100B and 5105A; Power Cable, Decade Test Cable, Connecting Cable to 5110B Driver (permits approx 2.5 ft vertical separation—longer cables available). 5110B: Power Cable.

** Interference compliance requires that the 5100B/5105A and 5110B are connected by a low inductance path such as adjacent rack mounting.

SIGNAL GENERATORS TO 40 GHz

Signal generators

Hewlett-Packard offers a complete line of easy to use HF, VHF, UHF, and SHF signal generators covering frequencies between 10 kHz and 40 GHz. This line includes new solid-state generators and synthesized signal generators as well as a complete line of performance-proven vacuum tube signal generators. Each includes the following features:

1) accurate, easy to read, frequency calibration
2) accurately calibrated variable output level
3) constant, well-matched, output impedance
4) wide modulation capability
5) low RF leakage
6) low harmonic content
7) freedom from spurious output or incidental modulation.

These features ensure the utmost convenience and accuracy for all kinds of measurements and signal simulations, including receiver sensitivity, selectivity or rejection, signal-to-noise ratio, gain bandwidth characteristics, conversion gain, antenna gain, and transmission line characteristics, as well as power to drive bridges, slotted lines, filter networks, etc.

New solid-state generators

This new group of signal generators offers all the advantages of solid-state design, such as increased portability, ruggedness, and reliability, while still retaining the outstanding signal quality characteristic of Hewlett-Packard's older vacuum tube signal generators. In addition these generators offer many new features not found on the older generators such as digital frequency readout (8640B, 8660B), ability to count external signals (8640B), field portability (8654A) and complete remote programming (8660A, 8660B).

HF to UHF

The newest member of the solid-state family is the 8640 signal generator covering 450 kHz to 550 MHz (frequency

Signal generator summary

Model	Frequency range	Characteristics	Page
8660A/B Synthesized Generator	.01 to 110 MHz 1 to 1300 MHz	1 Hz frequency resolution, 3 x 10^{-8}/day stability. Calibrated output from +13 to −146 dBm. Completely TTL programmable. Plug-ins determine frequency range and AM/FM capability	270
606A/B Signal Generator	50 kHz to 65 MHz 606B also has:	output 3 V to 0.1 μV, mod. BW dc to 20 kHz, low drift and noise, low incidental FM, low distortion, auxiliary RF output, stabilized phase lock capability	274
8708A Synchronizer	50 kHz to 455 MHz	companion for 606B or 608F permitting 2/10, continuous settability and stability, FM and phase modulation	274
8601A Generator Sweeper	100 kHz to 110 MHz	±1% of frequency dial accuracy, cal output +20 to −110 dBm into 50 ohms, leveled to ±0.25 dB, very low drift, residual FM and RFI leakage, 30% AM, 75 kHz dev FM, aux output, crystal cal	286
608E Signal Generator	10 to 480 MHz	output 1 V to 0.1 μV, into 50-ohm load; AM, pulse modulation, direct calibration, leveled power output, aux RF output	275
608F Signal Generator	10 to 455 MHz	output 0.5 V to 0.1 μV into 50 ohms, amplitude, pulse modulation, direct calibration, low incidental FM and drift, leveled output, aux RF output, stabilized phase lock capability	275
8640A/B Signal Generator	0.5–512 MHz	output +19 to −145 dBm into 50Ω; AM, FM, and ext. pulse modulation, direct calibration, leveled output. 8640B has built-in counter and phase-lock capability. All solid state	.
3200B Oscillator	10–500 MHz	1 V to 1 μV output into 50Ω, 120 dB attenuator range .002% stability, compact, portable; weight, 15 lbs	272
8654A Signal Generator	10–500 MHz	output 0 to −120 dBm into 50Ω, direct calibration, leveled output, amplitude and frequency modulation, solid-state, compact, weight 16 lbs	273
612A Signal Generator	450 to 1230 MHz	output 0.5 V to 0.1 μV into 50-ohm load; pulse or square-wave modulation, direct calibration	277
614A Signal Generator	0.8 to 2.1 GHz	output at least 0.5 mW to −127 dBm (0.1 μV) into 50 ohms, pulse or frequency modulation, direct calibration	279
8614A Signal Generator	0.8 to 2.4 GHz	output +10 to −127 dBm into 50 ohms, leveled below 0 dBm; internal square-wave; external pulse, AM and FM; auxiliary RF output	278
8614B Signal Source	0.8 to 2.4 GHz	output 15 mW; precision attenuator 130 dB range; internal square-wave, external pulse and FM; auxiliary RF output	278
616B Signal Generator	1.8 to 4.2 GHz	output 1 mW to −127 dBm (0.1 μV) into 50-ohm load, pulse or frequency modulation, direct calibration	279
8616A Signal Generator	1.8 to 4.5 GHz	output +3 to −127 dBm into 50 ohms, leveled below 0 dBm; internal square-wave, external pulse, AM and FM; auxiliary RF output	278
8616B Signal Source	1.8 to 4.5 GHz	output 3 mW; precision attenuator 130 dB range; internal square-wave, external pulse and FM; auxiliary RF output	278
618C, 620B Signal Generators	3.8 to 7.6 GHz 7 to 11 GHz	output 1 mW to −127 dBm (0.1 μV) into 50 ohms, pulse, frequency or square-wave modulation, direct calibration, ext FM and pulse modulation, auxiliary RF output	280
626A, 628A Signal Generators	10 to 15.5 GHz 15 to 21 GHz	output +10 dBm to −90 dBm; pulse, frequency or square-wave modulation, direct calibration	281
938A, 940A Frequency Doublers	18 to 26.5 GHz 26.5 to 40 GHz	driven by 9 to 13.25 GHz source, 13.25 to 20 GHz source, HP 626A, 628A, 8690 series sweepers or klystrons; 100 dB precision attenuator.	281

coverage can be extended to 1100 MHz with an external doubler, and an optional built-in audio oscillator extends the CW output range down to 20 Hz). This new generator is available in two models: the 8640B featuring a built-in 550 MHz counter and the 8640A with a mechanical slide rule frequency dial.

The 8640B with built-in counter includes two significant new features not previously found on Hewlett-Packard signal generators: 1) the ability to count external signals at frequencies up to 550 MHz and 2) a front panel pushbutton to phase-lock the generator's RF output to the built-in counter time base for frequency stability of better than 5×10^{-8}/hour.

Both models of the 8640 are leveled to within 0.5 dB across the full band and provide AM, FM, and pulse modulation for a wide range of receiver test applications. AM and FM can be performed independently or simultaneously in either the internal or external modes, and modulation is calibrated and metered for direct readout under all operating conditions.

Internally, the heart of the 8640 is a mechanically tuned high-Q cavity oscillator that operates over the range of 230 to 550 MHz. This oscillator has very good inherent stability and exceptionally low noise characteristics. Nine lower frequency ranges are obtained by dividing down the basic oscillator frequency and filtering out the unwanted harmonics. Using this technique, subharmonic and non-harmonic spurious responses are virtually eliminated.

The 8640's broad frequency coverage and calibrated output range, together with full AM/FM modulation capability and exceptionally low noise, make it the ideal choice for complete RF and IF performance tests on virtually any type of HF, VHF, or UHF receiver.

Compact, field portable

Compact, portable signal generators form another part of the solid-state family. The 8654A covering 10 to 500 MHz features calibrated output level with a full range attenuator and both AM and FM modulation capability. Small size and light weight make it well suited for field maintenance and operational readiness checks in addition to general purpose signal generator applications.

The 8601A covering 100 kHz to 110 MHz is a unique instrument with full sweep capability in addition to AM/FM modulation and a wide range output attenuator. Hewlett-Packard microcircuit technology is used extensively in the 8601A to provide this broad range of performance in a very small package.

Synthesized signal generators

The 8660 Synthesized Signal Generator family combines the signal stability and resolution of a frequency synthesizer with the modulation and output level calibration of a high quality signal generator.

For maximum versatility the 8660 family utilizes plug-in RF sections and modulation sections. Two RF sections provide frequency coverage of 10 kHz to 110 MHz and 1 MHz to 1300 MHz respectively. Modulation section plug-ins include calibrated AM and FM modulation capability as well as external pulse modulation.

Two mainframes, the 8660A and 8660B accept the plug-ins. The 8660A utilizes ten thumbwheel switches to select frequency with 1 Hz resolution. The 8660B, with its pushbutton keyboard, provides many features not previously found on frequency synthesizers, such as dial tuning of the synthesized output frequency, synthesized digital sweep, and pushbutton frequency increment capability. Both mainframes also include complete TTL programming of frequency, output level and modulation, and an interface kit is available for direct connection to any Hewlett-Packard computer.

The synthesized signal generator is a natural choice for applications requiring maximum signal stability, very fine frequency resolution, or programmability. For example, with the AM/FM modulation plug-in installed, the 8660A or 8660B is ideally suited for high stability receiver testing. The digital sweep capability of the 8660B coupled with its 1 Hz frequency resolution and excellent spectral purity make it an ideal choice for designing and testing high-Q devices such as crystal filters. With its full digital programming interface, the 8660 is also an ideal RF source for automatic systems.

Performance-proven vacuum tube signal generators

Hewlett-Packard's tube-type signal generators offer signal quality, versatility, and ease of operation which over the years has made them the standards of the industry.

HF to UHF

The HP 606A, 606B, 608E, 608F, and 612A signal generators collectively cover frequencies from 50 kHz to 1.23 GHz. All feature extremely low drift and incidental frequency modulation, and may be amplitude (sine, square, pulse) modulated.

A feedback loop in the 606A and 606B keeps their output and percent modulation constant as frequency is varied. The 608E and 608F also offer leveled output power resulting in significant time saving and convenience when the generator is being used to conduct tests at several frequencies. The 606B, 608E, and 608F offer an auxiliary fixed-level CW signal which can be applied to a counter for very accurate indication of carrier frequency.

The HP 606B and 608F contain voltage variable capacitors in their oscillator circuits enabling phase-locked operation with the HP Model 8708A RF Synchronizer. Frequency settability and stability of 2×10^{-7} can be obtained without compromise of the modulation or attenuation characteristics. This permits continuous frequency response examination of devices such as highly selective narrow-band filters, and adds phase and frequency modulation capability to the 606B and 608F Signal Generators.

UHF to SHF

A complete line of Hewlett-Packard microwave signal generators provides coverage from 800 MHz to 21 GHz. The 614A, 616B, 618C, 620B, 626A, and 628A incorporate cavity tuned klystron oscillators with very low drift and residual FM. They may be pulse, square-wave and frequency modulated, making them useful for microwave receiver testing as well as SWR and transmission line measurements.

The HP 8614A and 8616A signal generators covering 0.8 to 2.4 GHz and 1.8 to 4.5 GHz feature built-in PIN diode modulators. These modulators allow in-

SIGNAL GENERATORS

Special purpose signal sources

Application	Frequency range	Modulation	Output	Model	Page
Test, calibrate FM receivers	54 to 216 MHz	FM, AM	0.2 V	202H	348
Test, calibrate FM receivers	195–270 MHz	FM, AM	0.2 V	202J	348
Down converter for 202H, 202J	100 kHz to 55 MHz	See specifications		207H	348
Telemetry tests	1430 to 1540 MHz; 2150 to 2310 MHz	FM	−10 to −127 dBm	3205A	354
VOR/ILS tests	88 to 140 MHz	AM	0.2 V	211A	354
ILS/Glide Slope tests	329.3 to 335 MHz	AM	0.2 V	232A	354
DME/ATC tests	962 to 1213 MHz	Pulse	−10 dBm	8925A	354

ternal or external output power leveling as well as a wide range of pulse and amplitude modulation.

HP 938A and 940A Frequency Doubler Sets provide low-cost signal generator capability in the 18 to 40 GHz range. Designed to be driven by signal sources in the 9 to 20 GHz range, the frequency doublers preserve the versatility and stability of the driving source. Thus, the signals may be CW, pulsed or swept. An output monitor and precision attenuator provide a metered output, even though the input signal is uncalibrated.

Special signal generators

Hewlett-Packard's FM signal generators offer unusual modulation linearity and stability. The 202H FM-AM Signal Generator operates in the 54 to 216 MHz range and is designed to serve the broadcast FM, VHF-TV, and mobile communications markets. The 202J FM-AM Signal Generator is specifically designed for VHF telemetry and covers the 195 to 270 MHz frequency range. An accessory 207H Univerter provides additional coverage when used with either the 202H or 202J Signal Generators.

The 211A Signal Generator is specifically designed for the testing and calibration of aircraft VOR and ILS localizer receivers; an external modulator, such as the Collins 479S-3, is required to provide simulated course and bearing. The 232A Glide Slope Signal Generator is specifically designed for the testing and calibration of ILS glide slope receivers. The 8925A DME/ATC Test Set is designed to provide complete facilities for the testing and calibration of aircraft DME radios and ATC transponders; suitable external modulators are required, such as the Collins 578D-1 and 578A-1, to simulate ground station operation.

Signal generator accessories

A variety of available accessories enhance the operation of Hewlett-Packard signal generators. The HP 10511A Spectrum Generator and HP 10515A Frequency Doubler extend the usable frequency range of signal sources/generators up to 1 GHz. The HP 11507A Output Termination provides three useful positions for matching 50Ω signal generators to other than 50Ω impedances and the HP 11687A allows 50Ω generators to be used for measurement in 75Ω systems. The HP 11509A Fuseholder protects generator output attenuators against accidental burnout during transceiver testing. HP 10514A and 10534A Balanced Mixers offer varied mixing as well as AM, pulse and squarewave modulation applications.

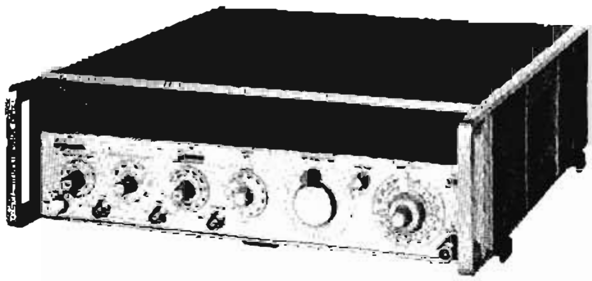
The HP 8730 series of PIN modulators increases the modulation capability of microwave signal sources and at the same time virtually eliminates incidental FM. The HP 8403A Modulator provides complete control of the 8730 series of PIN modulators, supplying the bias wave-shapes and levels for fast rise times, rated on-off ratios and amplitude modulation as well as providing pulse and square wave signals for direct application to signal sources.

AM-FM SIGNAL GENERATORS

Precision, versatile receiver testing 0.5 to 512 MHz

Models 8640A, 8640B

8640A



8640B

Features

8640A

- Wide frequency and power range
- Low broadband and close-in noise
- Calibrated, metered AM and FM
- 10 ppm/10 minutes stability

8640B (all 8640A features plus)

- Internal pushbutton synchronizer
- External counter to 550 MHz
- Six digit LED display

Applications

- Precision receiver testing
- High stability CW source
- Laboratory test instrument

Description

The 8640 signal generator covers the frequency range 500 kHz to 512 MHz (450 kHz to 550 MHz with band overrange) and can be extended to 1100 MHz with an external doubler. An optional audio oscillator is also available to extend the CW output range of the generator down to 20 Hz. This broad coverage, together with calibrated output and modulation, provides for complete RF and IF performance tests on virtually any type of HF, VHF, and UHF receivers.

Both solid state generators 8640A and B have an output level range of +19 to −145 dBm (2 V to 0.013 μV) which is calibrated, metered, and leveled to within ±0.5 dB across the full frequency range of the instrument.

The 8640A/B generators provide AM, FM, and pulse modulation for a wide range of receiver test applications. This modulation is calibrated and metered for direct readout under all operating conditions.

Other significant features of the 8640A/B signal generators include: extremely low noise, built-in phase lock and counter (B version only) and front panel controls designed for operating convenience and flexibility.

Spectrally pure output signals

Noise performance of the 8640 is state-of-the-art for a solid-state generator. The high-Q cavity oscillator has been optimized with use of a low-noise microwave transistor for spectrally pure output signals.

At 20 kHz offsets from 230 to 450 MHz, SSB phase noise is >130 dB/Hz below the carrier level and rises to 122 dB/Hz at 550 MHz. This signal-to-noise ratio increases by approximately 6 dB for each division of the output frequency down to the broadband noise floor of better than 140 dB/Hz. This exceptional noise performance is also preserved during FM modulation and in the phase-locked mode of the 8640B.

Mechanical dial or built-in counter

There are two versions of the 8640 Signal Generators. One, the 8640A, has an easy-to-read slide rule dial with scales for each of the 10 output frequency ranges. There is an additional scale, to provide direct readout of the output frequency even in the EXTERNAL DOUBLER band, 512-1024 MHz.

The 8640B has the same performance features as the 8640A, but incorporates a built-in 550 MHz frequency counter and phase lock synchronizer.

The built-in 6-digit counter displays the output frequency and can also be used to count external input signals from 20 Hz to 550 MHz. This eliminates the need for a separate frequency counter in many measurement systems.

Internal pushbutton synchronizer

At the push of a button, the 8640B built-in phase lock synchronizer locks the RF output frequency to the crystal time base used in the counter. In this locked mode, the output stability is better than 5 x 10^{-8}/hr and the spectral purity and FM capability of the unlocked mode are preserved. For higher stability, it is possible to lock to an externally applied 5 MHz standard. Two 8640B's can also be locked together for various 2-tone measurements.

FM while phase locked

When phase locked, full FM capability is preserved down to modulation rates of <50 Hz. The narrow bandwidth of the phase lock loop (<5 Hz) provides for FM modulation up to 250 kHz rates and assures no degradation in noise from the unlocked mode. This crystal stability, coupled with the precision modulation and low noise, makes the 8640B ideal for testing narrowband FM or crystal-controlled receivers.

8640A/B Partial Specifications
(See Technical Data Sheet for Complete Specifications)

All specifications apply over the nominal Frequency Bands and over the top 10 dB of the output level vernier range unless otherwise specified.

Frequency characteristics

Range: 500 kHz to 512 MHz in 10 octave bands (to 1024 MHz with external frequency doubler).

Bands and band overlap: bands extend 10% below and 7% above the nominal frequency bands shown below.

Frequency bands (MHz)

0.5–1	8–16	128–256
1–2	16–32	256–512
2–4	32–64	Ext Doubler Band: 512–1024
4–8	64–128	

Fine tuning:

8640A and 8640B unlocked: >200 ppm total range.

8640B locked mode: >±20 ppm by varying internal time base vernier.

Counter resolution (8640B):

Frequency Bands (MHz)	Normal Mode	Expand X10	Expand X100
0.5–1	10 Hz	1 Hz	0.1 Hz
1–16	100 Hz	10 Hz	1 Hz
16–128	1 kHz	100 Hz	10 Hz
128–1024	10 kHz	1 kHz	100 Hz

Accuracy:

8640A, mechanical dial; accuracy better than 0.5%, resettability better than 0.1%.

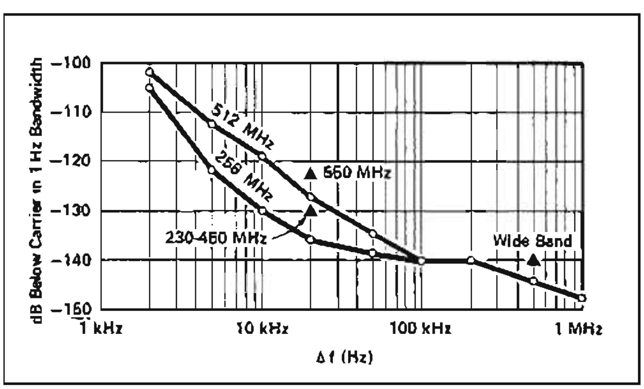
8640B, 6-digit LED display with X10 and X100 expand; accuracy depends on internal or external reference used.

[Total Count Accuracy] = [Counter Resolution (±1 count)] + [Reference Error (INT or EXT)] + [Reference Aging Error]

Internal reference error (15°C to 35°C): <±1 ppm.
Internal crystal aging rate: <2 ppm/year.

Stability (after 2-hr warm-up):
Normal: <10 ppm/10 min.
Locked: (8640B) <0.05 ppm/hr.

Restabilization time after frequency change:
Normal: <15 min.
Locked (8640B): none after relocking.



Measured SSB Noise vs. Offset from Carrier. Markers indicate specified limits.

Output characteristics

Range: continuously selectable from +19 to −145 dBm (2 V to 0.013 μV) into 50Ω.

Level accuracy: (worst case as indicated on level meter) +19 to −7 dBm, ±1.5 dB; −7 to −47 dBm, ±2.0 dB; −47 to −137 dBm, ±2.5 dB; −137 to −145 dBm, ±3.0 dB.

Level flatness: <±0.5 dB from 0.5 to 512 MHz referred to output at 50 MHz. (Flatness applies to 1 V output range and below and for top 10 dB of vernier range.)

Impedance: 50Ω, VSWR <2.0 on 2 V and 1 V output ranges. VSWR <1.3 on all other ranges.

Auxiliary output: rear panel BNC output is >−5 dBm into 50Ω, source impedance is approximately 500Ω.

Leakage (with all unused outputs terminated properly): leakage limits are below those specified in MIL-I-6181D. Furthermore, less than 3μV is induced in a 2-turn, 1-inch diameter loop 1 inch away from any surface and measured into a 50Ω receiver, and less than 1 μV, 2 inches away. This permits receiver sensitivity measurements to at least <0.03 μV in a shielded system.

Spectral purity

Harmonics: (at 1 volt (+13 dBm) output range and below)
>35 dB below fundamental of 0.5 to 128 MHz.
>30 dB below fundamental of 128 to 512 MHz.

Subharmonics and nonharmonic spurious: (excluding line-related sidebands)
8640A: none detectable; 8640B: >100 dB below carrier.

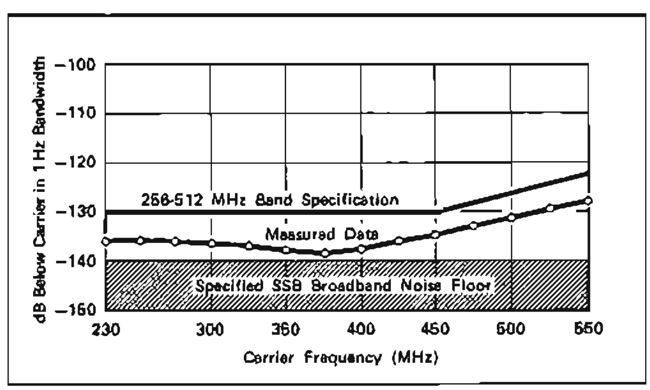
Noise: averaged RMS noise level below carrier stated in a 1 Hz bandwidth.

SSB phase noise at 20 kHz offset from carrier.

256 MHz to 512 MHz: >130 dB down from 230 to 450 MHz increasing linearly to >122 dB down at 550 MHz.

0.5 MHz to 256 MHz: decreases 6 dB for each divided frequency range until it reaches SSB broadband noise floor of >140 dB down.

Residuals	Post-detection Bandwidth	
	300 Hz to 3 kHz	20 Hz to 15 kHz
Residual AM:	>85 dB down	>78 dB down
Residual FM:		
CW and up to ⅛ ΔF max. peak dev. (ΔF)	<5 Hz <15 Hz	<15 Hz <30 Hz



Specified Signal to Phase Noise Ratio at 20 kHz Offset vs. Carrier Frequency

8640A/B Partial Specifications (cont'd)

Modulation characteristics

General

Types: Int AM and FM, Ext AM, FM and PULSE.

Internal modulation sources: (independently adjustable output is available at front panel).

Standard: 8640A or 8640B.

Frequency: fixed 400 Hz and 1 kHz, ±2%.

Output level: 10 mV to 1 V. Accuracy ±20%.

Optional: (internal variable audio oscillator Option 001, 8640A or 8640B).

Frequency: variable 20 Hz to 600 kHz, ±10% plus fixed 400 Hz and 1 kHz ±2%.

Output level: 10 mV to 3 V. Accuracy ±20%.

Amplitude modulation

(AM specifications apply to the top 10 dB of output vernier range unless otherwise specified.)

Depth: 0 to 100% for output level range of +13 dBm and below and for top 10 dB of vernier range.

AM rates: INT and EXT ac; 20 Hz to AM 3 dB bandwidth below. EXT dc; dc to AM 3 dB bandwidth below.

AM 3 dB bandwidth:

Freq. Bands	0 to 50% AM	70% AM	90% AM
0.5–2 MHz	25 kHz	20 kHz	12.5 kHz
2–8 MHz	50 kHz	40 kHz	25 kHz
8–512 MHz	100 kHz	80 kHz	50 kHz

AM distortion: (at 400 Hz and 1 kHz rates).

Freq. Bands	0 to 50% AM	70% AM	90% AM
0.5 to 512 MHz	<1%	<3%	<5%

External AM sensitivity: 0.1% AM per mV peak into 600Ω with AM vernier at full cw position; accuracy ±5%.

Indicated AM accuracy: (400 Hz and 1 kHz rates using internal meter) ±9% of meter reading.

Peak incidental PM: (at 30% AM).

Less than 0.15 radians, 0.5 to 128 MHz.

Less than 0.3 radians, 128 to 512 MHz.

Peak incidental FM: equals PEAK INCIDENTAL PM x MODULATION FREQUENCY.

Pulse Modulation:

Frequency Bands (MHz)	0.5 - 1	1 - 2	2 - 4	4 - 8	8 - 32	32 - 512
Rise and Fall Times	<9 μs	<4 μs	<2 μs	<1.5 μs	<0.5 μs	<0.5 μs
Pulse Repetition Rate	50 Hz to 50 kHz		50 Hz to 100 kHz		50 Hz to 250 kHz	50 Hz to 500 kHz
Pulse Width Minimum[1]	10 μs		5 μs		2 μs	1 μs
ON/OFF ratio at vernier	>40 dB					
Peak Input Required:	>1 V (5 V max) Sinewave or Pulse return to zero into 50Ω					

[1] For level accuracy within 1 dB of CW (>0.1% duty cycle).

Frequency modulation

Deviation: maximum allowable deviation equals 1% of lowest frequency in each nominal output frequency band.

FM 3 dB bandwidth:
Internal and external ac; 20 Hz to 250 kHz.
External dc; dc to 250 kHz.

FM distortion: (at 400 Hz and 1 kHz rates)
<1% for deviations up to ⅛ maximum allowable.
<3% for maximum allowable deviation.

External FM sensitivity: 1 volt peak yields maximum deviation indicated on PEAK DEVIATION switch with FM vernier at full CW position; accuracy ±5%.

Indicated FM accuracy: (using internal meter) ±9% of meter reading, above 10% of full scale.

Incidental AM: (at 400 Hz and 1 kHz rates)
<0.5% AM for FM up to ⅛ max. allowable deviation.
<1% AM for FM at maximum allowable deviation.

Counter characteristics (8640B)

External RF input:

Frequency range: 20 Hz to 550 MHz.

Sensitivity: ≥100 mV rms into 50Ω.

Resolution: 6-digit LED DISPLAY

Mode	Normal	Expand X10	Expand X100
0–10 MHz 0–550 MHz	100 Hz 10 kHz	10 Hz 1 kHz	1 Hz 100 Hz

Internal reference characteristics: (after 2-hr. warmup).

Accuracy: (after calibration at 25°C)
Better than ±1 ppm for 15° to 35°C.
Better than ±3 ppm for 0° to 55°C.

Drift rate: (constant temperature and line voltage)
<0.05 ppm over any hour period; <2 ppm per year.

Frequency tuning:
>±20 ppm using internal time base vernier.

Rear output: >0.5 V pk-pk into 500Ω. This will drive another 8640B.

External reference input: 5 MHz, >0.2 V (5 V max.) into 1 kΩ.

General characteristics

Operating temperature range: 0 to 55°C.

Power requirements: 100, 120, 220, and 240 volts, +5%, −10%, 48 to 440 Hz; 175 VA maximum.

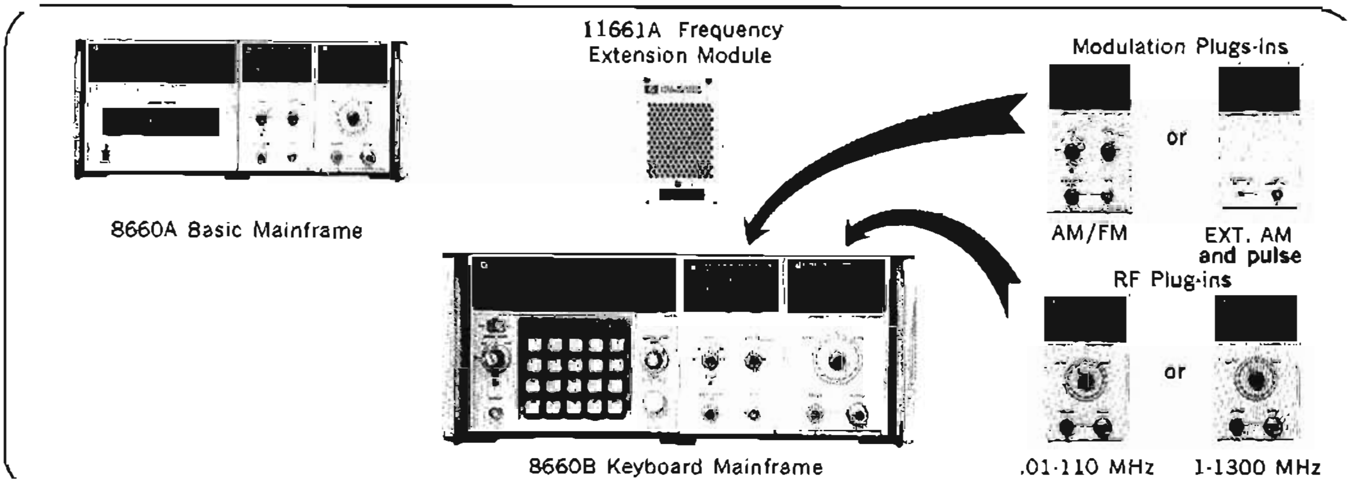
Weight: 8640A and 8640B: net, 45 lb (20,5 kg); shipping, 53 lb (24,1 kg).

Dimensions: 5¼″ high x 16¾″ wide x 18¾″ deep (13,4 x 42,5 x 47,6 cm).

Price: 8640A, $3100; 8640B, $4450.

Option 001: (internal variable audio oscillator, 20 Hz to 600 kHz) 8640A or 8640B, add $150.

SYNTHESIZED SIGNAL GENERATORS
Programmable, 10 kHz to 1300 MHz
Models 8660A, 8660B



Features

- Frequency coverage to 1.3 GHz
- 1 Hz frequency resolution
- −80 dB spurious
- 3×10^{-8}/day stability
- Plug-in RF and modulation sections
- Completely TTL programmable

Applications

- Programmable RF source for automatic systems
- Precision receiver testing
- L.O. in high stability communication systems
- Laboratory frequency standard
- Swept testing of narrowband devices

The 8660A/B family is a modular plug-in system. Each complete system includes: 1) an all solid-state synthesized signal generator mainframe, 2) at least one RF section plug-in, and 3) either a modulation section or the 86631B Auxiliary Section Plug-in.

Mainframes

There are two different synthesized signal generator mainframes to choose from. Both feature complete TTL programming of frequency, output level, and modulation. Both mainframes can also be operated either from the internal 10 MHz crystal reference oscillator or an external frequency standard at 1 MHz, 2 MHz, 5 MHz, or 10 MHz.

The 8660A Mainframe uses front panel thumbwheel switches to select CW output frequency with a resolution of 1 Hz. An optional version of the mainframe with 100 Hz resolution is also available. Wth the 86601A Option 001 RF Section and 86631B Auxiliary Section plug-ins installed, the 8660A is an ideal programmable RF source for automatic systems. With the standard 86601A RF Section and the 86632A AM/FM Modulation Section installed, the 8660A becomes a complete Synthesized Signal Generator.

The 8660B keyboard mainframe combines all the capability of the 8660A with a keyboard control panel. Added capabilities of the 8660B include digital sweep, frequency stepping, synthesized search, and a ten digit numerical LED display.

Swept testing of very narrowband devices such as crystal filters is made possible by the 8660B's digital sweeping capability. The selected sweep width is divided into either 100 or 1000 discrete steps depending on the sweep speed selected, and the RF output is synthesized at each step. The result is a very linear sweep with extremely low residual FM.

For receiver testing and similar applications which require frequency to be changed in uniform increments, a frequency stepping capability is provided on the 8660B. For example, if a receiver with 50 kHz channel spacing is being tested, 50 kHz can be entered on the keyboard. Then the step↑ or step↓ buttons will step the frequency to the next higher channel or lower channel respectively.

A unique synthesized search provides the dial tuning convenience of a signal generator while maintaining synthesizer signal quality. As the dial is rotated, the output frequency is tuned up or down in discrete synthesized steps which may be chosen as small as 1 Hz. When the 8660B is used as a local oscillator in a manual communication receiver, the synthesized search dial is very helpful in quickly locating unknown signals while maintaining the full-spectral purity of the synthesizer.

The ten-digit LED readout provides a continuous display of the selected CW or center frequency, with spring-loaded push-buttons to display sweep width, frequency step size, or a partially entered new command.

Plug-in RF sections

Two RF sections are presently available for 8660 Mainframes. The 86601A covers the 10 kHz to 110 MHz frequency range with a calibrated output of +13 dBm to −146 dBm. The 86602A, used in conjunction with the 11661A Frequency Extension Module, covers 1 MHz to 1300 MHz with a calibrated output of +10 to −146 dBm. Both RF sections have 1 Hz frequency resolution and in the remote mode output level can be programmed in 1 dB steps over the full operating range.

Plug-in modulation sections

The 86632A Modulation Section provides AM and FM modulation capability. Internal modulation is provided at 400 Hz and 1 kHz. A switch selects ac or dc coupling of external modulation inputs. A modulation meter indicates AM percent or FM peak deviation. The 86632A is completely programmable through the 8660 Mainframe

The 86631B Auxiliary Section is an economical, non-programmable modulation plug-in which provides both external AM and pulse modulation capability. Providing necessary interconnections for mainframe operation, the 86631B must be used when another modulation plug-in is not installed.

8660A/B Partial Specifications

(Refer to Technical Data Sheet for complete specifications)

8660A/B Synthesized Signal Generator Mainframes

Frequency accuracy and stability: CW frequency accuracy and long term stability are determined by reference oscillator in 8660A/B Mainframe (3 x 10^{-8}/24 hours) or by external reference if used.

Reference oscillator

Internal: 10 MHz quartz oscillator. Aging rate less than ±3 parts in 10^8 per 24 hours after 72 hr warmup. (±3 parts in 10^9 per 24 hours optional, Option 001).

External: rear panel switch allows operation from any 1 MHz, 2 MHz, 2.5 MHz, 5 MHz, or 10 MHz signal at a level between 0.2 V and 2.0 V rms into 170 ohms.

Reference output: rear panel BNC connector provides output of reference signal selected at a level of at least 0.5 V rms into 170 ohms.

Remote programming

Functions

8660A: all front panel frequency, output level, and modulation functions are programmable.

8660B: CW frequency, frequency stepping (STEP↑, STEP↓), output level, and modulation are programmable.

Switching time: less than 5 ms to be within 100 Hz of any new frequency selected. Less than 100 ms to be within 5 Hz of any new frequency selected.

Maximum stepping rate: 1 ms per step.

Programming input

Connector type: 36-pin Cinch Type 57 (mating connector supplied).

Logic: TTL compatible (negative true).

General

Operating temperature range: 0° to +55°C.

Power: 115 or 230 V ±10%, 50 to 60 Hz; approx 200 W.

Size: 16¾" wide, 7¼" high, 21⅝" deep (426 x 184 x 550 mm).

Weight: net, 49 lbs (22,0 kg); shipping, 63 lbs (28,4 kg).

Price: Model 8660A, $4900; Model 8660B, $6000.

Options for 8660A and 8660B

Option 001: ±3 x 10^{-9}/24 hrs; internal reference oscillator; add $200.

Option 002: no internal reference oscillator; less $350.

Option 003: operation from 50 to 400 Hz line; add $150.

Option 004: 100 Hz frequency resolution; less $500.

Option 009 (8660A only): LED Display indicates selected frequency in 1-2-4-8 BCD code; price: add $200.

Option 100: 11661A factory installed; price: add $2,000.

86601A RF Section

Frequency range: 0.01 to 110 MHz; selectable in 1 Hz steps.

Output level: continuously calibrated from +13 to −146 dBm into 50 ohms; programmable in 1 dB steps.

Harmonics: < −40 dB.

Spurious: < −80 dB.

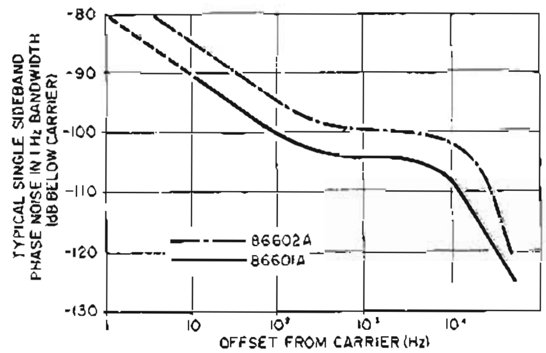
Amplitude modulation: (with 86631B or 86632A) 0 to 95%; maximum rate, 50 kHz at output frequencies above 4 MHz.

Frequency modulation: (with 86632A) maximum rate, 1 MHz; maximum deviation, 1 MHz.

Weight: net, 11 lbs (5 kg); shipping, 13 lbs (5,9 kg).

Price: Model 86601A, $1975.

Options: Option 001: no RF output attenuator; output level adjustable from +13 to 0 dBm; less $600.



Typical Phase Noise Curves for 86601A and 86602A

86602A RF Section

Frequency range: 1 to 1300 MHz; selectable in 1 Hz steps.

Output level: continuously calibrated from +10 to −146 dBm into 50 ohms; programmable in 1 dB steps.

Harmonics: < −30 dB at output levels below +3 dBm.

Spurious

Non-line related: below 700 MHz −80 dB; above 700 MHz −80 dB within 45 MHz of carrier, −70 dB >45 MHz from carrier.

Line related: −70 dB.

Amplitude modulation: (with 86631B or 86632A) 0 to 95% maximum rate, 50 kHz.

Frequency modulation: (with 86632A) maximum rate, 200 kHz; maximum deviation, 200 kHz.

Weight: net, approx 9 lbs (3,9 kg); shipping, 11 lbs (5,0 kg).

Options: same as 86601A.

Price: Model 86602A, $2800.

11661A Extension Module

Must be installed in 8660A/B Mainframe to enable operation of 86602A RF Section.

Weight: net, approx 4 lbs (1,8 kg); shipping, 5 lbs (2,2 kg).

Price: Model 11661A, $2000.

86632A Modulation Section

Provides AM/FM capability as described above when used with 86601A or 86602A RF Section. Includes modulation meter and 400 Hz and 1 kHz internal oscillators; completely programmable.

Weight: net, 6 lbs (2,5 kg); shipping, 7 lbs (3,2 kg).

Price: Model 86632A, $900.

86631B Auxiliary Section

The 86631B must be installed in an 8660A/B Mainframe when the modulation section is not used. A jack is provided on the front panel to allow external AM and pulse modulation. A PULSE LEVEL vernier is provided to continuously adjust peak pulse power.

Weight: net, 2 lbs (0,9 kg); shipping, 4 lbs (1,8 kg).

Price: Model 86631B, $90.

VHF OSCILLATOR
10 to 500 MHz; to 1000 MHz with accessory Probe
Model 3200B

The HP 3200B VHF Oscillator provides low cost, stable, 10 to 500 MHz RF for testing receivers and amplifiers, and driving bridges, slotted lines, antennas, and filter networks. Good pulse modulation sensitivity allows standard audio oscillators to be used to provide usable square-wave modulation; a 2.5-volt sine wave will provide adequate drive for this type application. The 3200B can also serve as a local oscillator for heterodyne detector systems and as a marker source for swept systems. An optional accessory Frequency Doubler Probe, HP 13515A, provides additional frequency coverage from 500 to 1000 MHz.

The 3200B will typically recover specified stability in 30 minutes following a frequency band change. Long-term warmup (24 hours) can reduce this time as much as 50%. Following in-band frequency dial changes, the oscillator typically requires 10 minutes to recover specified stability. With the instrument in thermal equilibrium with its surroundings, (i.e., long-term warmup and constant temperature lab), stabilities of 0.0001% are typical at some frequencies, if sufficient settling time is allowed after a frequency change.

Effective RF shielding permits measurements at levels down to 1 μV.

RF is read on an expanded slide-rule type scale. The oscillator may be precisely tuned by means of a mechanical vernier activated by the main tuning control.

3200B

13515A

Specifications

Frequency range: 10 to 500 MHz in six bands: 10 to 18.8 MHz; 18.5 to 35 MHz; 35 to 68 MHz; 68 to 130 MHz; 130 to 260 MHz; 260 to 500 MHz.

Frequency accuracy: within ±2% after ½ hour warmup.

Frequency calibration: increments of less than 4%.

Frequency stability (after 4-hour warmup under 0.2 mW load): short term (5 minutes) ±0.002%; long term (1 hour) ±0.02%; line voltage (5-volt change) ±0.001%.

RF output:

Maximum power (across 50-ohm external load): >200 mW (10 to 130 MHz); >150 mW (130 to 260 MHz); >25 mW (260 to 500 MHz).*

Range: 0 to >120 dB attenuation from maximum output.

Load impedance: 50 ohms nominal.

RF leakage: sufficiently low to permit measurements at 1 μV.
RFI: meets requirements of MIL-I-6181D.

Amplitude modulation: externally modulated.

Range: 0 to 30%.

Distortion: <1% at 30% AM.

External requirements: approximately 20 volts rms into 600 ohms for 30% AM, 200 Hz to 100 kHz.

Pulse modulation: externally modulated.

External requirements: 2.5-volt negative pulse into 2000 ohms.

Power: 105 to 125 V or 210 to 250 V, 50 to 400 Hz. 30 W.

Dimensions: 7⅝" wide, 6½" high. 13⅛" deep (194 x 165 x 333 mm).

Weight: net, 15 lbs (6,8 kg); shipping, 17 lbs (7,7 kg).

Accessories available: 13515A Frequency Doubler Probe; 00501B, 00514B, 00517B Output Cables; 00502B, 00506B Patching Cables.

Price: HP 3200B, $595; HP 13515A, $95.

*For higher RF power output, to 4.5 watts, use of the 230B Power Amplifier is recommended. See page 35.

VHF SIGNAL GENERATOR
Rugged solid-state generator 10-512 MHz
Model 8654A

Features

- Calibrated output power
- Automatic power leveling
- AM, FM internal, external, independent
- Rugged, lightweight, solid state
- Compact size and shape

Applications

- Receiver sensitivity, S/N ratio
- Antenna and filter characteristics
- Field maintenance and servicing
- Production and mobile test stations

The HP 8654A Signal Generator is a portable, low-cost, solid state generator providing calibrated output and versatile modulation capabilities over the 10 to 512 MHz frequency range. The 8654A provides stable RF signals for testing receivers, amplifiers, antennas and filter networks.

Its compactness and small size allow the 8654A to fit easily into production, mobile, airborne and shipboard test locations. Its rugged, lightweight construction is also suitable for field maintenance and service applications.

Internal oscillators provide both amplitude modulation and frequency modulation at 400 Hz and 1000 Hz or external modulation can be accomplished using standard audio oscillators. The front panel meter accurately indicates amplitude modulation percentage from 0-90% by using the AM meter mode switch.

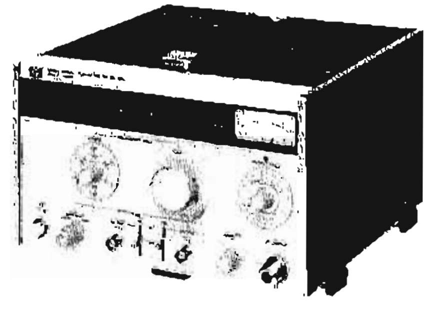
Output power is automatically leveled to ±1 dB over the entire frequency range of +10 dBm and below, and the power level is variable over more than a 120 dB dynamic range. The 10 dB-step attenuator and 13 dB vernier allow continuous selection of power settings over the entire output range. The front panel meter displays the output power in dBm and volts and always indicates the calibrated level.

An auxiliary uncalibrated RF output is also available at the rear panel for use with a counter or other external equipment. Auxiliary output level is a minimum of −10 dBm.

The 8654A has a specified stability of 0.002% over a 5 minute operating period after a one-hour warmup. It will typically recover specified stability within 5 minutes following a frequency band change.

Effective RF shielding and output range permit receiver sensitivity measurements to be made down to power levels of 1.0 μV.

Its compact size and shape combined with its stability and versatility make the HP 8654A a high-value VHF signal generator for economy-minded applications.



8654A

Specifications, 8654A

Frequency characteristics

Range: 10-512 MHz in 6 bands:

10-18.8 MHz	18.8-35 MHz	35-65 MHz
65-125 MHz	125-250 MHz	240-512 MHz

Accuracy: ±2% after 30 min warmup.

Stability: .002%/5 min after 1 hr warmup and 5 min after changing frequency bands; .002%/10% change in line voltage.

Residual FM: 5 x 10^{-7} peak.

Output characteristics

Maximum power (into 50Ω): >+10 dBm from 10 to 512 MHz.

Attenuator range: 10 dB steps and a 13 dB vernier provide continuous power settings from maximum power output to −120 dBm. Output is absolutely calibrated in volts and dBm and is monitored by the front panel output meter.

Level accuracy: ±1.5 dB plus attenuator accuracy.

Attenuator accuracy: −7 to −57 dBm, ±0.5 dB; −57 to −127 dBm, ±1.5 dB.

Level flatness: ±1 dB from 10-512 MHz for output level 10 dBm and below.

Load impedance: 50Ω nominal, VSWR: 1.2.

RF leakage: permits receiver sensitivity measurements down to at least 1.0 μV. (Conducted and radiated leakage limits are below those specified in MIL-I-6181D.)

Modulation characteristics

(Specifications apply for carrier power level of +3 dBm and below and for the top 10 dB of the vernier range.)

Internal AM

Frequency: 400 Hz and 1 kHz ±10% available at front panel.

Modulation level: 0 to 90% AM continuously adjustable with the modulation "level" control.

Carrier envelope distortion: <2% to 50% AM; <6% at 90% AM.

External AM

Frequency: dc to 10 kHz for 30% AM; dc to 5 kHz for 90% AM.

Input level required: nominal 1 volt peak at external AM input yields full modulation. Carrier voltage can be varied from 0 to ±90% by an external dc input of 0 to ±1 V nominal.

Carrier envelope distortion: <2% at 30% AM; <6% at 90% AM.

Modulation meter accuracy: ±5% of f.s. for 0.90% AM.

Internal FM: 400 Hz and 1000 Hz internal oscillator. >0.1% peak deviation, 10 to 100 MHz. >100 kHz peak deviation, 100 to 512 MHz.

External FM: DC to 2 kHz bandwidth from 600Ω source. DC to 10 kHz bandwidth from 50Ω source. Deviation same as internal FM.

Input level required: 15 volt peak for maximum peak deviation.

General

Power: 100, 120, 220, or 240 V +5%, −10%, 48 to 440 Hz, approximately 20 W.

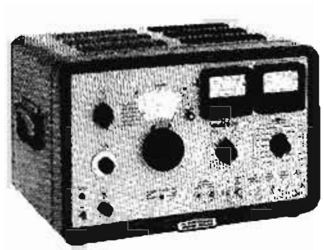
Dimensions: 6½" x 10½" x 12" deep (165 x 266 x 321 mm).

Weight: 16 lbs (7,4 kg); shipping 22 lbs (10 kg).

Price: $1,135.

HF SIGNAL GENERATORS AND HF-VHF SYNCHRONIZER

Models 606A, 606B, 8708A



606B

The Hewlett-Packard 606B Signal Generator provides high quality operation in the 50 kHz to 65 MHz frequency range. Output signals are stable and accurately known. Output amplitude can be precisely established over a +23 to −120 dBm dynamic range with versatile modulation capabilities.

Specifications, 606B

Frequency and output characteristics

Range: 50 kHz to 65 MHz in 6 bands; accuracy: ±1%.

Drift: (1 V output and below) less than 50 ppm (or 5 Hz, whichever is greater) per 10 min period after 2-hr warmup; less than 10 min to restabilize after changing frequency.

Stability when used with 8708A Synchronizer: 5×10^{-9}/min, 2×10^{-7}/10 min, 2×10^{-6}/day; 2×10^{-7}/°C, 0° to 55°C; 2×10^{-7}/10% line voltage change.

△F control: better than 10 ppm settability; range of △F control approx 0.1%.

Resetability: better than 0.15% after warmup.

Crystal calibrator: provides frequency checkpoints every 100 kHz and 1 MHz; jack provided for audio frequency output; crystal frequency accuracy better than 0.01% from 0°-50°C.

Residual FM: less than ±1 ppm or ±20 Hz peak, whichever is greater.

Frequency control input: front panel input can be used with 8708A Synchronizer and external frequency control; limits: 0 to −50 V, 4 kΩ nominal input impedance.

Output level: continuously adjustable from 0.1 μV to 3 V into 50-ohm resistive load, calibrated in voltage and dBm.

Frequency response and output accuracy: at output below 1 V, output variation with frequency is less than 2 dB; output accuracy is better than ±1 dB at any frequency.

Impedance: 50 ohms, SWR less than 1.2 on 0.3 V attenuator range and below.

RFI: meets all conditions specified in MIL-I-6181D; permits receiver sensitivity measurements down to at least 1.0 μV.

Harmonic output: at least 30 dB below the carrier.

Spurious AM: hum and noise sidebands are 70 dB below carrier down to thermal level of 50-ohm output system.

Auxiliary RF output: on front panel for use with HP 8708A Synchronizer or other external equipment. Minimum output: 100 mV rms into 50 ohms from 50 kHz to 19.2 MHz, 200 mV rms from 19 to 65 MHz.

Modulation characteristics

Internal AM:

Frequency: 400 and 1000 Hz, ±5%.

Modulation level: 0 to 95% on 1 V attenuator range and below; 0 to at least 30% on 3 V range.

Incidental FM (attenuator on 1 V range and below, 30% modulation): less than 5×10^{-6} + 100 Hz peak.

Carrier envelope distortion: <1% at 30% AM, <3% at 70% AM (attenuator on 1 V range and below).

External AM:

Frequency: dc to 20 kHz maximum, dependent on carrier frequency (f_c) and percent modulation as tabulated.

Maximum modulation frequency:

30% Mod:	70% Mod:	Squarewave Mod:
0.06 f_c	0.02 f_c	0.003 f_c (3 kHz max.)

Modulation level: 0 to 95% on 1 V attenuator range and below, 0 to at least 30% on 3 V range.

Input required: 4.5 V peak produces 95% modulation (maximum input 50 V peak); input impedance 1000 ohms.

Carrier envelope distortion: same as for internal AM.

Modulation meter accuracy: ±5% of full scale, 0 to 90%, for modulation frequencies to 10 kHz, ±10% of full scale for frequencies from 10 kHz to 20 kHz.

Modulation level constancy (internal or external AM; attenuator on 1 V range and below): modulation level stays constant within ±1/2 dB regardless of carrier frequency and output level changes.

General

Power: 115 or 230 V ±10%, 50 to 400 Hz, 135 W.

Dimensions: cabinet, 20¾" wide, 12½" high, 14¾" deep. (527 x 318 x 370 mm); rack, 19" wide, 10½" high, 14⅜" deep behind panel, (483 x 266 x 367).

Weight: cabinet, net, 55 lb (24,8 kg); shipping 65 lb (29,3 kg); rack, net, 50 lb (22,5 kg); shipping 63 lb (28,4 kg).

Accessories available (See Page 356):

11507A Output Termination, provides 3 positions: 50 ohms, 5 ohms and IEEE Standard Dummy Antenna.

11509A Fuseholder, protection for 606B transceiver tests.

10534A Mixer, for use as a nanosecond pulse modulator.

Price: HP 606B (cabinet), $1730; HP 606BR (rack), $1715.

Model 606A

The Model 606A covers the same frequency range as the 606B but does not include an auxiliary uncalibrated RF output or the frequency control feature with the 8708A. 606B specifications apply to the 606A except: harmonic output is less than 3%, output power level frequency response is ±1 dB.

Price: HP 606A (cabinet), $1680; HP 606AR (rack), $1665.

8708A Synchronizer

The 8708A Synchronizer is a phase-lock frequency stabilizer that provides crystal-oscillator frequency stability in the 606B (and 608F) signal generators to 430 MHz. The outstanding AM and output level control capabilities of the signal generators are retained. Phase-locking eliminates microphonics and drift, resulting in a frequency stability of 2×10^{-7} per 10 minutes, an increase by a factor of 250.

Specifications, 8708A

Frequency range: 50 kHz to 430 MHz; phase-locks 606B and 608F signal generator, with 2×10^{-7} settability.

Weight: net, 27 lb (12,2 kg); shipping 31 lb (14 kg).

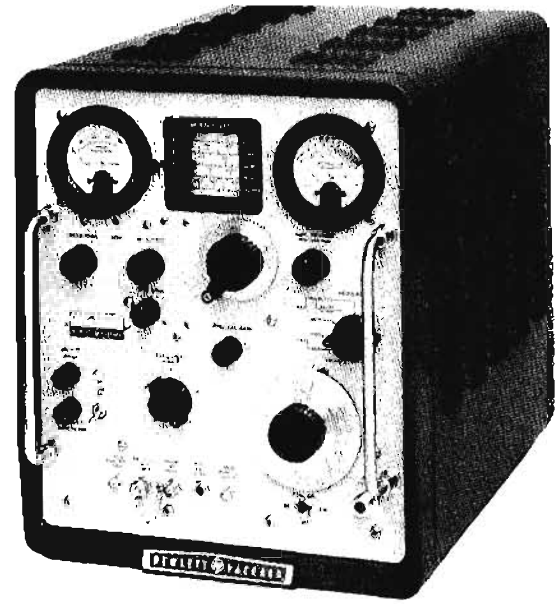
Price: Model 8708A, $2050.

VHF SIGNAL GENERATORS

Versatility and value, 10-480 MHz

Models 608E, 608F

Models 608E and 608F provide high-quality, versatile performance with distinctive ease of operation. The 608E provides an adjustable, calibrated output of 0.1 μV to 1 V rms from 10 to 480 MHz. The 608F is calibrated from 0.1 μV to 0.5 V rms over the 10-455 MHz frequency range and can be phase-locked with the 8708A Synchronizer for greater stability. An auxiliary RF output is available with both models.



608F

Specifications, 608E and 608F

Frequency characteristics

Range: 608E: 10-480 MHz; 608F: 10-455 MHz in 5 bands.

Accuracy: 608E: ±0.5%; 608F: ±1%.

Drift: 608E/F: less than 50×10^{-6}/10 min after one hr warmup. 608F: stability when used with 8708A Synchronizer: 5×10^{-8}/min; 2×10^{-7}/10 min; 2×10^{-6}/day; 2×10^{-7}/°C(0° to 55°C); 2×10^{-7}/10% line voltage change.

Frequency control input (608F only): front panel input can be used with 8708A Synchronizer and external frequency control; limits 0 to −50 V, 4 KΩ nominal input impedance.

Resettability: better than ±0.1% after initial warmup; fine-frequency-adjust provides approx 25 kHz settability at 480 MHz (608E).

Crystal calibrator: provides frequency check points every 1 MHz up to 270 MHz or every 5 MHz over total range; jack provided for audio frequency output; crystal frequency accuracy better than 0.01% at room temperatures.

Residual FM: less than ±5 parts in 10^7 peak.

Harmonic output: at least 35 dB below the carrier for harmonic frequencies below 500 MHz.

Output characteristics

Output level: continuously adjustable from 0.1 μV to 1.0 V (608E) and 0.1 μV to 0.5 V (608F) into a 50-ohm resistive load; output calibrated in volts and dBm.

Accuracy: within ±1 dB of attenuator dial reading at any frequency when RF output meter indicates "ATTENUATOR CALIBRATED."

Impedance: 50Ω with a maximum SWR of 1.2 for attenuator setting below −7 dBm.

RFI: meets all conditions specified in MIL-I-6181D; permits receiver sensitivity measurements down to at least 0.1μV.

Auxiliary RF output: 608E: at least 180 mV rms into 50Ω provided at front panel.

608F: front panel output for use with HP 8708A Synchronizer or other external equipment. Power levels into 50Ω are: 10 to 215 MHz, −1.8 to +7 dBm; 215 to 400 MHz, +2.0 to +7 dBm; 400 to 430 MHz +1.0 to +7 dBm.

Modulation characteristics

Internal AM

Frequency: 400 and 1000 Hz, ±10%.

Modulation level: 0 to 95% modulation at carrier levels 0.5 V and below (608E) and .224 V (1 mW) or below (608F).

Carrier envelope distortion: less than 2% at 30% AM, less than 5% at 70% AM.

External AM

Frequency: 20 Hz to 20 kHz.

Modulation level: 0 to 95% modulation at carrier levels of 0.5 V and below (608E) and at .244 V (1 mW) or below (608F): continuously adjustable with front panel MOD LEVEL control; input required, 1-10 V rms (1000Ω input impedance).

Carrier envelope distortion: less than 2% at 30% AM, less than 5% at 70% AM, (modulation source distortion less than 0.5%).

Modulation meter accuracy: ±5% of full scale 0 to 80%, ±10% from 80% to 95% (for INT AM or 20 Hz to 20 kHz EXT AM).

Incidental FM (at 400 and 1000 Hz modulation): less than 1000 Hz peak at 50% AM for frequencies above 100 MHz; below 100 MHz, less than 0.001% at 30% AM.

External pulse modulation

Rise and decay time: from 40 MHz to 220 MHz, combined rise and decay time less than 4 μs; above 220 MHz combined rise and decay time less than 2.5 μs.

On-off ratio: at least 20 dB for pulsed carrier levels of 0.5 V and above.

Input required: positive pulse, 10-50 V peak, input impedance 2000Ω.

General

Power: 115 or 230 V ±10%, 50 to 400 Hz; approx 220 W.

Dimensions: cabinet: 13¼" wide, 16⅜" high, 21" deep (337 x 416 x 533 mm); rack rount: 19" wide, 13-31/32" high, 18⅜" deep behind panel (483 x 335 x 467 mm).

Weight: cabinet mount: net, 62 lbs (28 kg); shipping, 74 lbs (33,4 kg); rack mount: net, 62 lbs (28 kg); shipping, 83 lbs (37,4 kg).

Accessories available: (see page 556).

11508A Output Cable for high impedance circuits.

11509A Fuse Holder: protection for transceiver tests.

10514A Mixer for use as nanosecond pulse modulator.

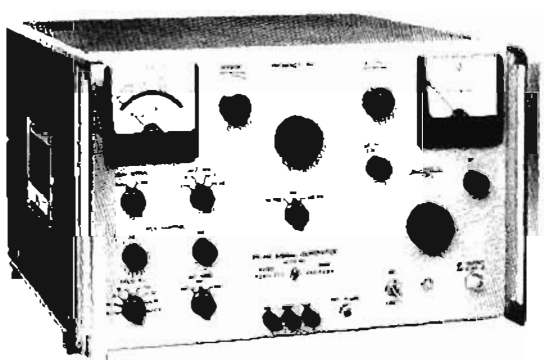
Price: Model 608E (cabinet), $1930; Model 608ER (rack mount), $1975; Model 608F (cabinet), $2090; Model 608FR (rack mount), $2130.

FM-AM SIGNAL GENERATORS
FM, AM, CW and pulse coverage, 54-270 MHz
Models 202H, 202J, 207H

202H, 202J

The HP 202H FM-AM Signal Generator covers the frequency range 54 to 216 MHz and is designed for the testing and calibration of FM receiving systems in the areas of broadcast FM, VHF, TV, mobile and general communications.

The HP 202J FM-AM Signal Generator covers the frequency range from 195 to 270 MHz and is designed for the testing and calibration of FM telemetering receiving systems in the 215 to 260 MHz band.



202H

Specifications, 202H, 202J

Radio frequency characteristics

RF range: 202H, 54 to 216 MHz; 202J 195-270 MHz.
RF accuracy (after 1 hr warm-up): main dial, ±0.5%; electronic vernier, ±(10% + 1 kHz).
RF stability: 202H: <0.01%/hr; 202J: <0.02%/hr, after 2-hour warm-up.
RF output: range 0.1 μV to 0.2 V (across external 50-ohm load at panel jack); accuracy: ±10%, 0.1 μV to 50 mV; ±20%, 50 mV to 0.2 V; auto level set: holds RF monitor meter to "red line" over band; impedance: 50 ohms; VSWR: <1.2; spurious output: all spurious RF output voltages are at least 25 dB (202J) and 30 dB (202H) below desired frequency.
RF leakage: sufficiently low to permit measurements at 0.1 μV.

Amplitude modulation characteristics

AM range: internal, 0 to 50%; external, 0 to 100%.
AM accuracy: ±10% of reading at 400 Hz at 30% and 50%.
AM calibration: 30, 50, 100%.
AM distortion: <5% at 30%, <8% at 50%, <20% at 90%.
AM fidelity: ±1 dB, 30 Hz to 200 kHz.

Frequency modulation characteristics

FM deviation range: internal or external, 0 to 250 kHz in 4 ranges (202H): 0 to 300 kHz (202J).
FM deviation accuracy: ±5% of full-scale (for 400 Hz sine wave).
FM distortion (202H only): <0.5% at 75 kHz (100 MHz), <1% at 75 kHz (54 to 216 MHz), <10% at 250 kHz (54 to 216 MHz); at 400 Hz modulation frequency.
FM non-linearity (202J only): <1.5% at 150 Hz, <5% at 300 kHz ("least squares" departure from straight line passing through origin).
FM fidelity 202H: ±1 dB, 5 Hz to 200 kHz.
202J: ±1 dB, 5 Hz to 500 kHz; ±3 dB, 3 Hz to 1 MHz.

Pulse modulation characteristics

Source: external; rise time: 202H ≤0.6 μs; 202J <0.25 μs; fall time: <0.8 μs.

Modulation oscillator characteristics

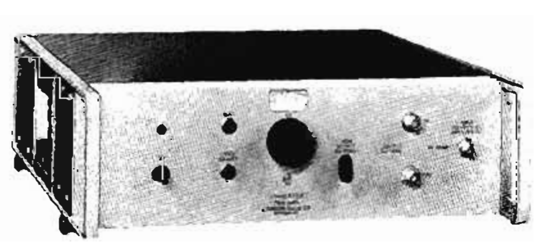
Osc frequency 202H: 50 Hz, 400 Hz, 1000 Hz, 3000 Hz, 7.5 kHz, 10 kHz, 15 kHz, 67 kHz; **202J:** 50 Hz, 400 Hz, 1700 Hz, 3900 Hz, 10.5 kHz, 30 kHz, 70 kHz, 100 kHz.
Osc accuracy: ±5%.
Osc distortion: <0.5%, except <1.0% at 67 kHz for 202H.

General

Dimensions: 16¾" wide, 10¼" high, 18⅜" deep (425 x 260 x 467 mm).
Weight: net, 47 lbs (20,3 kg); shipping, 66 lbs (29,7 kg) for 202H.
Power: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 100 W.
Accessory furnished: 00502B patching cable.
Price: HP 202H, $1750; HP 202J, $1875.
Option 001: Aux. RF output >50 mV, (202J only), add $150.

207H

The HP 207H Univerter is a frequency converter with unity gain designed for use with the HP 202H and 202J Signal Generators to provide additional frequency coverage from 100 kHz to 55 MHz. The 207H duplicates AM & FM of the 202H and 202J with no appreciable distortion for input levels less than 50 mV.



207H

Major Specifications, 207H

(When used with 202H and 202J Signal Generators.)

RF range: 100 kHz to 55 MHz (with 199.9 to 145 MHz input from 202H; 200.1 to 255 MHz input from 202J).
RF output: 1 μV to 0.1 V and 0.01 μV to 1 mV across external 50-ohm load at panel jack; >1 V with 0.1 V input and 300-ohm output load.
Power: 105 to 125 V or 210 to 250 V, 50 to 400 Hz, 50 W.
Price: HP 207H $650.

UHF SIGNAL GENERATOR
All-purpose UHF signal generator, 450 to 1230 MHz
Model 612A

Here is an all-purpose, precision signal generator particularly designed for utmost convenience and applicability throughout the important UHF-TV frequency band. It is ideally suited for measurements in UHF-television broadcasting, studio-transmitter links, citizen's radio and public service communications systems. The HP 612A also covers the important frequencies used in aircraft navigation aids such as DME, TACAN and airborne transponders. Accessory modulators, available from many of the manufacturers of these navigational aids, enable the 612A to provide the complex modulation patterns required for testing and aligning these systems. In the laboratory, the 612A is a convenient power source for driving bridges, slotted lines, antennas and filter networks. In addition, the HP 8731 PIN Modulators can be used with the 612A to obtain RF pulses with 30 ns rise time and 0.1 μs minimum duration—with on-off ratios approaching 80 dB.

MOPA circuit

The master oscillator-power amplifier circuit in the HP 612A provides 0.5 volt into 50 ohms over the full frequency range of 450 to 1230 MHz. There is very low incidental FM (less than 0.002% at 30% AM) and excellent amplitude modulation capabilities by all frequencies from 20 Hz to 5 MHz. The degree of modulation is easily read from the large percent modulation meter. The instrument can be amplitude-modulated (either internally or externally), and provision is made for external pulse modulation as well. Pulse modulation can be applied to the amplifier or directly to the oscillator when high on-off signal ratios are required (signal may be completely cut off between pulses). Modulation can be up or down from a preset level to simulate TV modulation characteristics accurately.

Advanced design

The oscillator-amplifier circuit in the 612A employs high-frequency pencil triodes in a cavity-tuned circuit for precise tracking over the entire band. Noncontacting cavity plungers are die-cast to precise tolerances, then injection-molded with a plastic filler for optimum Q. The frequency drive is a direct screw-operated mechanism, free from backlash. A waveguide-beyond-cutoff piston attenuator and crystal monitor circuit are used to ensure accurate, reliable output down to 0.1 μV. The attenuator is calibrated over a range of 131 dB and has been carefully designed to provide a constant impedance-versus-frequency characteristic. The SWR of the 50-ohm output system is less than 1.2 over the complete frequency range.

612A

Specifications

Frequency range: 450 to 1230 MHz in one band; scale length approximately 15" (381 mm).

Calibration accuracy: within ±1%; resettability better than 5 MHz at high frequencies.

Output voltage: 0.1 μV to 0.5 V into 50-ohm load; calibrated in V and dBm (0 dBm = 1 mW).

Output accuracy: ±1 dB, 0 to −127 dBm over entire frequency range.

Output impedance: 50 ohms; maximum reflection coefficient, 0.091 (1.2 SWR, 20.8 dB return loss) for attenuator settings of 0 dBm and below.

Amplitude modulation: above 470 MHz, 0 to 90% at audio frequencies, indicated by panel meter; accuracy ±10% of full scale, 30 to 90% modulation.

Incidental FM: less than 0.002% for 30% AM.

Internal modulation: 400 and 1000 Hz ±10%; envelope distortion less than 3% at 30% modulation.

External modulation: 20 Hz to 5 MHz; above 470 MHz, 2 V rms produces 85% AM at modulating frequencies up to 500 kHz, at least 40% AM at 5 MHz; modulation may be up or down from the carrier level or symmetrical about the carrier level; positive or negative pulses may be applied to increase or decrease RF output from the carrier level.

Pulse modulation

Pulse 1 (pulse applied to amplifier): positive or negative pulses, 4 to 40 V peak produce an RF on-off ratio of at least 20 dB; minimum RF output pulse length, 1.0 μs.

Pulse 2 (pulse applied to oscillator): positive or negative pulses, 4 to 40 V peak; no RF output during off time; minimum RF output pulse length, 1.0 μs.

RFI: conducted and radiated leakage limits are below those specified in MIL-I-6181D; permits receiver sensitivity measurements down to 1 μV.

Power: 115 or 230 volts ±10%, 50 to 400 Hz, 215 watts.

Dimensions: cabinet: 13½" wide, 16½" high, 21½" deep (333 x 419 x 546 mm); rack mount: 19" wide, 13-31/32" high, 20¼" deep behind panel (483 x 355 x 514 mm).

Weight: net, 56 lbs (25,2 kg); shipping, 68 lbs (30,6 kg) (cabinet); net, 56 lbs (25,2 kg); shipping, 77 lbs (34,6 kg) (rack mount).

Accessories available: 11500A RF Cable Assembly; 10503A Video Cable Assembly; 360B Low-Pass Filter (may be used where harmonic output must be reduced to a minimum, as in slotted line measurements).

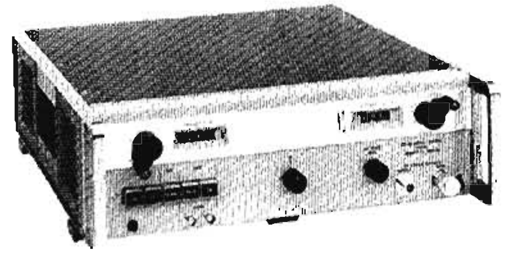
Price: HP 612A, $1950 (cabinet); HP 612AR, $1990 (rack mount).

SIGNAL GENERATORS, SOURCES

Stable, easy to use, 800 to 4500 MHz

Models 8614A, 8616A, 8614B, 8616B

8614A



8614B

HP 8614A, 8616A Signal Generators

The HP 8614A and 8616A Signal Generators provide stable, accurate signals from 800 to 2400 MHz (8614A) and from 1800 to 4500 MHz (8616A). Both frequency and attenuation are set on direct-reading digital dials, while selectable functions include CW, leveled output, square-wave modulation, and external AM, FM and pulse modulation. Modulation can be accomplished simultaneously with or without leveling.

Two RF power outputs are simultaneously available from separate front-panel connectors. One provides at least 10 mW (2 mW above 3000 MHz) or a leveled output from 0 to −127 dBm. The other is at least 0.5 mW across the band and is independent of attenuator setting. This signal can be used for phase-locking the signal generators for extreme stability, or it can be monitored with a frequency counter for extreme frequency resolution without adversely affecting the primary output.

A unique PIN diode modulator permits amplitude modulation from dc to 1 MHz or furnishes RF pulses with a 2 μs rise time. This broad modulation bandwidth permits remote control of output level or precise leveling using external equipment. The internal leveling is also obtained by using a PIN modulator.

HP 8614B, 8616B Signal Sources

The HP 8614B and 8616B retain the convenience of the "A" models. Although the signal sources do not have power monitors or internal PIN diode modulation, relative power measurements can be made, using the precision attenuator. Modulation capabilities include internal square-wave modulation, plus external pulse and frequency modulation. A friction clutch arrangement permits setting the attenuator dial to any suitable reference while output power is held constant. Thus, the attenuator can be calibrated directly in dBm or insertion loss.

Specifications

Frequency range: 8614A and 8614B, 800 to 2400 MHz; 8616A and 8616B, 1800 to 4500 MHz.

Leveled output: constant within ±0.75 dB (8614A) and ±1.0 dB (8616A) across entire frequency range at any attenuator setting below 0 dB. Not available with 8614B and 8616B.

Frequency calibration accuracy: 8614A, ±5 MHz; 8614B, ±5 MHz or ±0.5%, whichever is greater; 8616A, ±10 MHz; 8616B, ±10 MHz or ±0.5%, whichever is greater.

Vernier: ΔF control has a minimum range of 1.5 MHz for fine tuning (1.0 MHz for 8614B, 8616B).

Frequency stability

- **With temperature:** approximately 0.005%/°C change in ambient temperature.
- **With line voltage:** less than 0.003% change for line voltage variation of ±10%.
- **Residual FM:** 8614A and 8616A, less than 2500 Hz peak; 8614B, less than 0.0003% peak; 8616B, less than 6 kHz peak.

RF output power

- **8614A:** +10 dBm (10 mW) to −127 dBm (0.1 μV) into a 50-ohm load; output attenuator dial directly calibrated in dBm from 0 to −127 dBm.
- **8614B:** at least 15 mW max, controlled by attenuator.
- **8616A:** +10 dBm to −127 dBm into a 50-ohm load, 1800 to 3000 MHz; +3 dBm to −127 dBm into a 50-ohm load, 3000 to 4500 MHz; output attenuator directly calibrated in dBm from 0 to −127 dBm.
- **8616B:** at least 15 mW maximum, 1800 to 3000 MHz; at least 3 mW maximum, 3000 to 4500 MHz; controlled by attenuator.

Output impedance: 50 ohms nominal.

Reflection coefficient

- **8614A, 8616A:** less than 0.33.
- **8614B:** less than 0.2.
- **8616B:** less than 0.26.

Modulation

- **Internal square wave:** 950 to 1050 Hz, can be synchronized with a +1 to +10 volt input signal.
- **External AM (8614A, 8616A only):** dc to 1 MHz.
- **Incidental FM (8614A, 8616A only):** negligible for power levels below −10 dBm.
- **External pulse**
  - **8614A and 8616A:** 50 Hz to 50 kHz, 2 μs rise time, +20 to +100 volts input.
  - **8614B, 8616B (below 4000 MHz):** 50 Hz to 500 kHz; +25 to +50 volts peak input; minimum RF pulse width, 300 ns; RF rise time, typically 200 ns.
- **External FM:** (a) front-panel connector capacitively coupled to klystron repeller; input impedance, 220 kΩ shunted by approx 300 pF; (b) rear-panel connector is dc-coupled to the klystron repeller.

Power: 115 or 230 volts ±10%, 50 to 60 Hz, approx 125 watts.

Dimensions: 16¾" wide, 5½" high, 18⅜" deep (426 x 141 x 467 mm); hardware furnished for conversion to rack mount 19" wide, 5-7/32" high, 16⅜" deep behind panel (483 x 133 x 416 mm).

Weight: 8614A and 8616A: net, 44 lbs (19,8 kg); shipping, 48 lbs (22,0 kg), 8614B, 8616B: net, 38 lbs (17,1 kg); shipping, 44 lbs (19,4 kg).

Price: HP 8614A or 8616A, $2570; HP 8614B or 8616B, $1980.

Option 001: external modulation input connectors on rear panel in parallel with front-panel connectors; RF connectors on rear panel only, add $25.

UHF SIGNAL GENERATORS

Direct-reading, direct control, 800 to 4200 MHz

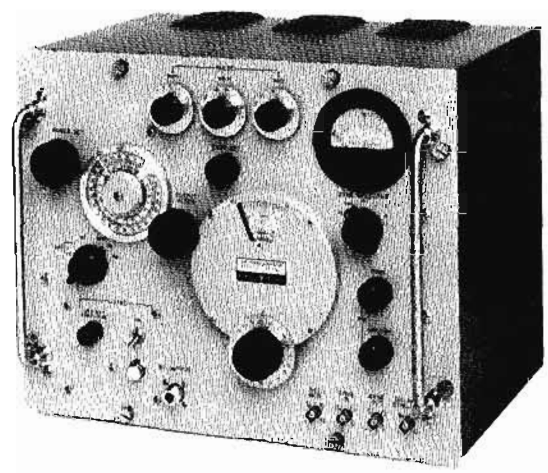
Models 614A, 616B

Ease of operation, direct-reading one dial frequency control, high stability and accuracy and broad frequency coverage are all advantages of these widely used signal generators.

The 614A covers frequencies from 800 to 2100 MHz, has constant output impedance with less than 1.6 SWR, and output accuracy of ±1.5 dB over the range of —10 dBm to —127 dBm. The 616B gives complete coverage of frequencies from 1.8 to 4.2 GHz, has constant output impedance with less than 1.8 SWR, and output accuracy of ±1.5 dB from —7 dBm to —127 dBm.

On both instruments, operation is extremely simple. Carrier frequency is set and read directly on the large tuning dial. No voltage adjustments are necessary during operation because of the coupling device which causes oscillator repeller voltage to track frequency changes automatically. Oscillator output is set and read directly on a simplified dial. Output may be continuous or pulsed, or frequency-modulated at power line frequency. Pulse modulation may be provided externally or internally. Internal pulsing may be synchronized with either positive or negative external pulses, or sine waves.

The oscillator portion of both the 614A and 616B consists of a reflex klystron in an external coaxial resonator. Frequency of oscillation is determined by a movable plunger which varies the resonant frequency of the resonator. Oscillator output is monitored by a temperature-compensated thermistor bridge circuit which is virtually unaffected by ambient temperature conditions. Voltage output is read directly. A logging scale on the frequency dial provides a resettability of 0.1%.



614A

Specifications

Frequency range: 614A, 800 to 2100 MHz; 616B, 1.8 to 4.2 GHz.

Frequency accuracy: ±1%.

Frequency stability: 0.005%/°C change in ambient temperature; line voltage changes of ±10% cause 0.01% frequency change.

Output power range (into 50-ohm load): 614A, 0.5 mW or 0.158 V to 0.1 μV (—3 to —127 dBm) from 800 to 900 MHz, 1 mW or 0.224 V to 0.1 μV (0 to —127 dBm) from 900 to 2100 MHz; 616B, 1 mW or 0.224 V to 0.1 μV (0 to —127 dBm).

Power accuracy (at the end of 6-ft output cable, terminated in 50-ohm load): 614A, within ±1.5 dB from —10 to —127 dBm; 616B, within ±1.5 dB from —7 to —127 dBm.

Output impedance: 614A, 50 ohms, reflection coefficient less than 0.23 (1.6 SWR, 12.7 dB return loss); 616B, 50 ohms, reflection coefficient less than 0.285 (1.8 SWR, 10.9 dB return loss).

Modulation: internal or external pulse or FM.

Internal pulse modulation: pulse repetition rate variable from 40 to 4000 per sec; pulse length variable from 1 to 10 μs; delay variable from 3 to 300 μs between synchronizing signal and RF pulse.

External pulse modulation: ext —: —40 to —70 V, 1 to 2500 μs wide, ext +: +40 to +70 V, 1 to 400 μs wide, square wave: ±40 to ±70 V p-p, 40 to 4000 Hz.

Trigger pulses out: (1) simultaneous with RF pulse; (2) in advance of RF pulse, variable from 3 to 300 μs (both approximately 1 μs rise time, amplitude +10 to +50 volts).

External synchronization: pulses, ±10 to ±50 V, 1 to 20 μs wide; may also be synchronized with sine waves.

Frequency modulation: oscillator sweeps at power line frequency; deviation and phase adjustable; maximum deviation approx 3 MHz p-p.

RFI: conducted and radiated leakage limits are below those specified in MIL-I-6181D.

Power: 115 or 230 V ±10%, 50 to 400 Hz, approx 160 W.

Dimensions: cabinet: 17¼" wide, 13⅝" high, 13½" deep (438 x 346 x 343 mm); rack mount: 19" wide, 13-31/32" high, 12⅛" deep behind panel (483 x 355 x 308 mm).

Weight: net, 58 lbs (26,4 kg); shipping, 66 lbs (30,0 kg).

Accessory furnished: 11500 A RF Cable Assembly.

Accessories available: 614A: 360C Low Pass Filter, f_c = 2200 MHz; 10503A Video Cable Assembly; 616B: S281A Waveguide-to-Coax Adapter, 2.6 to 3.95 GHz; G281A Waveguide-to-Coax Adapter, 3.95 to 5.85 GHz; 360D Low-Pass Filter, f_c = 4.1 GHz.

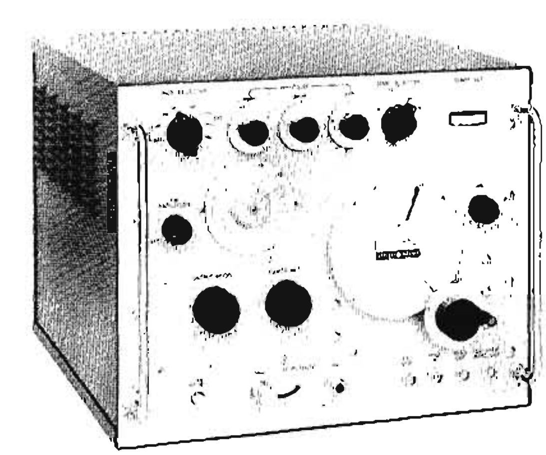
Price: HP 614A or HP 616B, $2700 (cabinet); HP 614AR or 616BR, $2740 (rack mount).

SHF SIGNAL GENERATORS

Multiple-purpose instruments, 3.8 to 11 GHz

Models 618C, 620B

The Models 618C and 620B SHF Signal Generators provide versatility, accuracy, and stability in the range from 3.8 to 11 GHz. Frequency is set on a large, direct-reading dial. A △F vernier control provides ultra-fine tuning capability. There is also a provision for remote fine tuning.



620B

A calibrated output from 0 to —127 dBm (0.224 volts to 0.1 microvolt) is also set on a large, direct-reading dial. The dial is calibrated in both dBm and volts. An auxiliary output of at least 0.3 milliwatt is available and is independent of attenuator setting. Thus, it can be used for phase-locking the signal generator when crystal-oscillator stability is required, or it can be monitored with a frequency counter for extreme frequency resolution.

The 618C and 620B Generators both feature oscillators of the reflex klystron type, with external resonant cavity. Oscillator frequency is determined by a movable plunger which varies the length of the cavity. Oscillator output is monitored by a temperature-compensated detector circuit. This circuit operates virtually unaffected by ambient temperature conditions.

Modulation includes internal pulse, square wave, and frequency modulation plus external pulse and frequency modulation.

Specifications

Output

Frequency range: 618C: 3,800 to 7,600 MHz covered in a single band; 620B: 7 to 11 GHz covered in a single band; repeller voltage automatically tracked and proper mode automatically selected.

Calibration: direct reading; frequency calibration accuracy better than ±1%.

Frequency stability: with temperature: less than 0.006%/°C change in ambient temperature; with line voltage less than 0.02% change for line voltage variation of ±10%; residual FM: <15 kHz peak.

Output range: 1 milliwatt or 0.224 volt to 0.1 microvolt (0 dBm to —127 dBm) into 50 ohms; directly calibrated in microvolts and dB; coaxial type N connector.

Output accuracy: within ±2 dB from —7 to —127 dBm, within ±3 dB from 0 to —7 dBm, terminated in 50-ohm load.

Source Impedance: 50 ohms nominal; reflection coefficient less than 0.33.

Modulation

Modulation: internal or external pulse, FM, and square wave.

Internal pulse modulation: repetition rate variable from 40 to 4,000 pps, pulse width variable ½ to 10 microseconds.

Sync out signals: simultaneous with RF pulse, positive; in advance of RF pulse, positive, variable 3 to 300 microseconds (better than 1 microsecond rise time and 25 to 100 volts amplitude into 1,000-ohm load).

External synchronization: sine wave: 40 to 4,000 Hz, 5 to 50 V rms; pulse: 40 to 4,000 pps, 20 to 70 V peak, positive or negative, 0.5 to 5 μs wide, 0.1 to 1 μs rise time.

Internal square-wave modulation: variable 40 to 4,000 Hz,

Internal FM: sawtooth sweep rate adjustable 40 to 4,000 Hz; frequency deviation to 5 MHz peak-to-peak over most of the frequency range.

External pulse modulation: pulse requirements: amplitude from 20 to 70 volts positive or negative, width 0.5 to 2,500 microseconds.

External FM: frequency deviation approximately 5 MHz peak-to-peak over most of the band; sensitivity approximately 20 V/MHz at front-panel connector, approximately 10 V/MHz at rear-panel connector (mating connector supplied); front-panel connector is capacitively coupled to klystron repeller; rear-panel connector is dc-coupled to klystron repeller and is suitable for phase-lock control input.

General

RFI: conducted and radiated leakage limits are below those specified in MIL-I-6181D.

Power source: 115 or 230 volts ±10%, 50 to 60 Hz 230 W.

Dimensions: cabinet, 17½″ wide, 13⅞″ high, 20⅜″ deep behind panel (445 x 353 x 518 mm); rack mount, 19″ wide, 13-31/32″ high, 19″ deep behind panel (483 x 355 x 483 mm).

Weight: net, 67 lbs (30,4 kg); shipping, 75 lbs (34,1 kg).

Accessory furnished: 11500A Cable Assembly, 6 feet (1830 mm) of RG-214A/U 50-ohm coax, terminated on each end by type N male connectors.

Price: Model 618C or 620B (cabinet mount), $2700. Model 618CR or 620BR (rack mount), $2740.

SHF GENERATORS/DOUBLERS
Generate stable signals, 10 to 40 GHz
Models 626A, 628A, 938A, 940A

626A, 628A

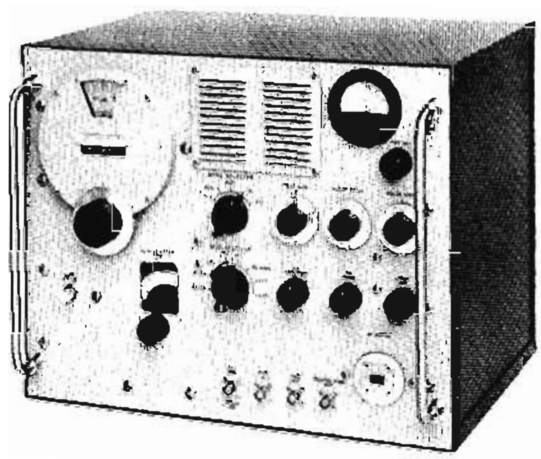
The 626A covers frequencies 10 to 15.5 GHz, and the 628A covers frequencies 15 to 21 GHz. In design and operation, the instruments are similar to Hewlett-Packard generators for lower frequency ranges. Carrier frequency is set and read directly on the large tuning dial. No voltage adjustment is necessary during tuning because repeller voltage is tracked with frequency changes automatically. Oscillator output also is set and read directly, and no frequency correction is necessary throughout operating range. A frequency logging scale permits frequency to be reset within 0.1%.

Both the 626A and 628A offer internal and external pulse, square-wave and frequency modulation. The pulse generators may be synchronized with an external sine wave and positive or negative pulse signals.

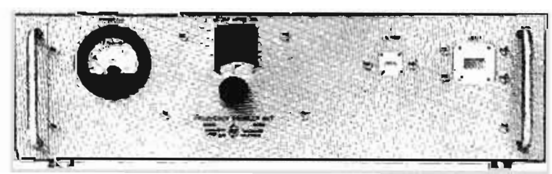
The high power output of these signal generators makes them ideally suited for driving HP 938A and 940A Frequency Doubler sets. These doubler sets retain the modulation and stability of the driving source and have accurate power monitors and attenuators.

Specifications, 626A, 628A

Frequency range: 626A, 10 to 15.5 GHz; 628A, 15 to 21 GHz.
Frequency calibration: dial direct-reading in GHz, accuracy better than ±1%.
Output range: 10 mW to 1 pW (+10 dBm to −90 dBm, 0 dBm = 1 mW); attenuator dial calibrated in output dBm.
Source impedance: 50 ohms nominal; reflection coefficient: 626A, less than 0.43 at +10 dBm, 0.15 at 0 dBm and below; 628A, less than 0.43 at +10 dBm, 0.091 at 0 dBm and below.
Output monitor accuracy: better than ±1 dB; temperature-compensated thermistor bridge circuit monitors RF oscillator power level.
Output connector: 626A: 0.850 x 0.475 inch waveguide, WR75, flat cover flange; 628A: 0.590 x 0.335 inch waveguide, WR51, flat cover flange.
Output attenuator accuracy: better than ±2% of attenuation in dB introduced by output attenuator.
Modulation: internal or external pulse, FM, or squarewave.
Internal pulse modulation: repetition rate variable from 40 to 4000 pps; pulse width variable 0.5 to 10 μs.
Internal square-wave modulation: variable 40 to 4000 Hz controlled by "pulse rate" control.
Internal frequency modulation: power line frequency, deviation up to 10 MHz p-p.
External pulse modulation: pulse requirements: amplitude 15 to 70 volts peak positive or negative; width 1 to 2500 μs.
External frequency modulation: provided by capacitive coupling to the klystron repeller; maximum deviation approx 10 MHz p-p.
Sync out signals: positive 20 to 50 V peak into 1000-ohm load; better than 1 μs rise time; 1) simultaneous with RF pulse, positive; 2) in advance of RF pulse, positive, variable 5 to 300 μs.
External synchronization: 1) sine wave, 40 to 4000 Hz, amplitude 5 to 50 V rms; 2) pulse signals 0 to 4000 pps, 5 to 50 V amplitude, positive or negative; pulse width 0.5 to 5 μs; rise time 0.1 to 1 μs.
Power: 115 or 230 volts ±10%, 50 to 60 Hz, approx 200 watts.
Dimensions: cabinet: 17" wide, 14" high, 15" deep (432 x 356 x 381 mm); rack mount: 19" wide, 14" high, 12-13/16" deep behind panel (483 x 356 x 313 mm).
Weight: 626A,AR: net, 59 lbs (26,8 kg); shipping, 68 lbs (31,3 kg); 628A,AR: net, 56 lbs (25,4 kg); shipping 65 lbs (29,5 kg).
Accessories furnished: 626A, MX 292B and MP 292B Waveguide Adapters; 628A, NP 292A and NK 292A Waveguide Adapters.
Accessories available: 10503A Video Cable Assembly for 626A: M362A low-pass filter.



628A



938A

Price: HP 626A or 628A, (cabinet) $4500 ; HP 626AR or 628AR, (rack mount), $4540

Frequency doubler sets

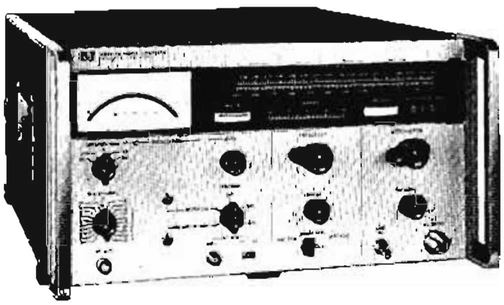
Model 938A supplies power from 18 to 26.5 GHz and Model 940A from 26.5 to 40 GHz when driven by 9 to 13.25 GHz and 13.25 to 20 GHz sources respectively. For a swept output, use a swept-frequency source such as Model 8690B or Model 8620A/B series with appropriate RF units.

Specifications, 938A, 940A

Frequency range: 938A, 18 to 26.5 GHz; 940A, 26.5 to 40 GHz.
Conversion loss: less than 18 dB at 10 mW input.
Output power: approximately 0.5-1 mW when used with typical 626A, 628A signal generators; input power: 100 mW maximum.
Output attenuator: accuracy, ±2% of reading or ±0.2 dB, whichever is greater; range, 100 dB.
Output reflection coefficient: approx 0.33 at full output; less than 0.2 with attenuator set to 10 dB or greater.
Input flange: 938A, M-band flat cover flange for WR-75 waveguide; 940A, N-band flat cover flange for WR-51 waveguide.
Output flange: 938A K-band flat cover flange for WR-42 waveguide; 940A R-band flat flange for WR-28 waveguide.
Dimensions: 19¼" wide, 5⅜" high, 18" deep (489 x 137 x 457 mm).
Weight: net, 20 lbs (9 kg); shipping, 26 lbs (11,8 kg).
Price: HP 938A or HP 940A, $2800.

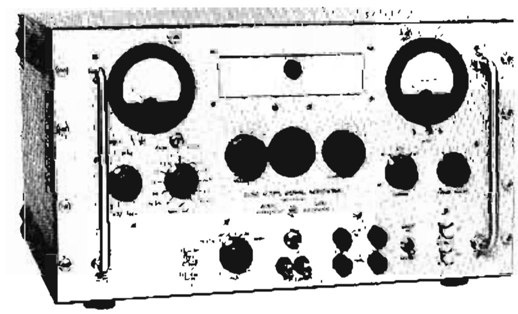
SPECIAL SIGNAL GENERATORS
Avionics and telemetry test equipment
Models 3205A, 211A, 232A, 8925A

Telemetry Test Equipment

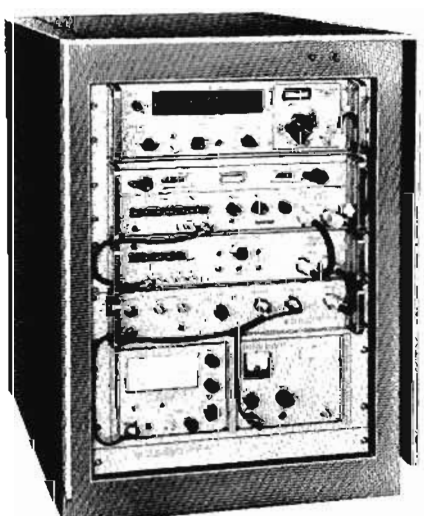


3205A

Avionics Test Equipment



232A



8925A

211AP1 211A

HP 3205A

The Model 3205A FM Signal Generator is a self-contained, completely solid-state instrument designed for use in the measurement and calibration of FM telemetry receivers in the 1435 to 1540 MHz and 2200 to 2300 MHz frequency bands. The generator has its own deviation meter calibration system that does not require external instrumentation. Calibrated RF output level, adjustable from —10 dBm to —127 dBm is also included. An internal modulation oscillator permits selection of channels 1 through 21 of the standard IRIG (Inter-range Instrumentation Group) subcarrier frequencies used for telemetry systems.

Frequency range: band 1, 1430 to 1540 MHz; band 2, 2150 to 2310 MHz.

Price: $6250.

Option 001: all front panel connectors moved to rear panel, add $50.

HP 232A

The FAA Instrument Landing System for aircraft includes a glide slope receiver for indicating the proper rate of descent. The HP 232A Glide Slope Signal Generator was designed for use in testing and calibrating these glide-slope receivers.

Frequency range: RF, 329.3 to 335 MHz in increments of 0.3 MHz; IF, 20.7 MHz; other frequencies between 15 and 30 MHz available on special order.

Price: HP 232A, $3200.

HP 8925A

The HP 8925A DME/ATC Test Set is specifically designed for testing and calibrating DME (Distance Measuring Equipment) and ATC (Air Traffic Control) transponder aircraft equipment. When used with suitable modulators, the test set will also simulate some TACAN and IFF signals. Completely self-contained (except for video modulators), the system consists of a continuously tuneable signal generator (HP 8614A Option H01), direct-reading frequency counter (HP 5245L), solid-state modulator (HP 8403A Option H01), frequency converter (HP 5254A), wavemeter (HP 8905A), peak power measuring system (HP 8900B), and all necessary circuitry for interconnection to the radio set under test (HP 13505A).

Frequency range: 962 to 1213 MHz.

Price: HP 8925A, $14,080.

Options: (specify by option number).

001: less 5245L/5254A Counter, $10,505.

002: less cabinet, $13,280.

003: dual power range (10 to 200/100 to 2000 W), add $130.

004: HP 5246L Counter instead of HP 5245L, $13,450.

HP 211A

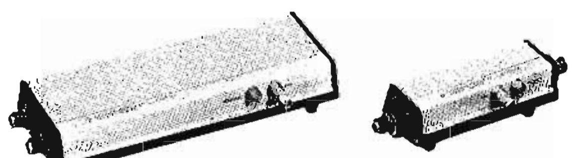
The HP 211A Crystal-Monitored Signal Generator is specifically designed for the testing and calibrating of aircraft VOR and ILS localizer radio receiving equipment operating within the frequency range from 88 to 140 MHz. It also may be used for laboratory and development work where a precision-type amplitude-modulated RF signal source is required.

Frequency range: master oscillator: 88 to 140 MHz in one range; crystal oscillator: 110.1 and 114.9 MHz.

Price: HP 211A, 211AP1 Power Supply, $2900.

PIN MODULATORS, MODULATORS

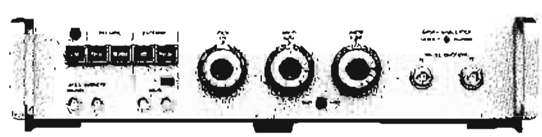
Versatile modulation
8730 Series, 8403A



8732A 8731B

8730 PIN Modulators

With HP 8730 series PIN Modulators, signal sources, including klystrons, can be pulse-modulated, leveled or amplitude-modulated with sinusoidal and complex waveforms. Fast rise-times, low incidental FM and a nearly constant impedance match to source and load are typical of these absorption-type modulators.



8403A

8403A Modulator

The Model 8403A provides complete control of the PIN modulators, supplying the appropriate modulation wave shapes and bias levels for fast rise times, rated on/off ratios and amplitude modulation. An internal square-wave and pulse modulator with PRF of 50 Hz to 50 kHz and adjustable pulse width and delay also provides square wave and pulses for general pulse applications. For applications requiring an absorption-type modulator plus controls in a single unit, a PIN modulator can be installed in the Model 8403A.

Specifications, 8403A

Output characteristics (available separately at front panel)

For driving 8730 PIN Modulators: AM and pulse output specially shaped for optimum RF rise and decay times.

For general pulse applications: positive dc-coupled pulse 25 to 30 volts in amplitude, approximately symmetrical about 0 volt; no AM signal.

Modulation

Internal square wave
- **Frequency:** variable from 50 Hz to 50 kHz.
- **Symmetry:** better than 45/55%.

Internal pulse
- **Repetition rate:** variable from 50 Hz to 50 kHz.
- **Delay:** variable from 0.1 μs to 100 μs, between sync out pulse and RF output pulse.
- **Width:** variable from 0.1 μs to 100 μs.

External sync
- **Signal:** 5 to 20 volts peak, + or −, pulse or sine wave.
- **Input impedance:** approx 2000 ohms, dc-coupled.

Trigger out
- **Sync out:** simultaneous with or 0.1 to 100 μs in advance of RF pulse, as set by delay control.
- **Delayed sync out:** simultaneous with output pulse.
- **Amplitude:** approximately −2 volts.
- **Source impedance:** approximately 330 ohms.

External pulse input
- **Amplitude and polarity:** 5 volts to 20 volts peak, + or −.
- **Repetition rate:** maximum average PRF, 500 kHz.
- **Input impedance:** approximately 2000 ohms, dc-coupled.
- **Width:** minimum 0.1 μs; maximum $\frac{1}{PRF}$ −0.4 μs.

Continuous amplitude modulation (with 8730 series)
- **Frequency response:** dc to approximately 10 MHz (3 dB).
- **Sensitivity:** approx 10 dB/volt with HP 8730A series; approx 20 dB/volt with HP 8730B series.
- **Input impedance:** approximately 100 ohms.

General

Power: 115 or 230 volts ±10%, 50 to 400 Hz, approx 10 watts.
Dimensions: 16¾" wide, 3¾" high, 18⅜" deep (425 x 96 x 467 mm); hardware furnished for rack mount 19" wide, 3-15/32" high, 16⅜" deep behind panel (483 x 89 x 416 mm).
Weight: net, 17 lbs (7,7 kg); shipping 20 lbs (9.5 kg).
Price: HP 8403A, $900.
Options: PIN Modulators installed

001	HP 8731A, add $525	002	HP 8731B, add $775
003	HP 8732A, add $525	004	HP 8732B, add $775
005	HP 8733A, add $525	006	HP 8733B, add $775
007	HP 8734A, add $525	008	HP 8734B, add $775
009	input and output connectors on rear panel, add $25.		

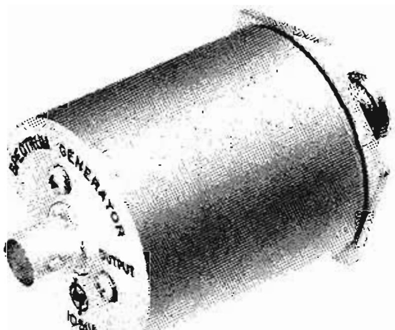
Specifications, 8730 Series

HP Model	8731A	8731B	8732A	8732B	8733A	8733B	8734A	8734B	8735A	8735B	H10-8731B[1]
Frequency range (GHz)	0.8-2.4	0.8-2.4	1.8-4.5	1.8-4.5	3.7-8.3	3.7-8.3	7.0-12.4	7.0-12.4	8.2-12.4	8.2-12.4	0.4-0.9
Dynamic range (dB)	35	80	35	80	35	80	35	80	35	80	35
Max. residual atten. (dB)[1]	<1.5	<2.0	<2.0	<3.5[2]	<2.0	<3.0	<4.0	<5.0	<4.0	<5.0	<2.0
Typical rise time (ns)[3]	40	30	40	30	30	30	30	30	30	30	40
Typical decay time (ns)[3]	30	20	30	20	20	20	20	20	20	20	30
SWR, min. attenuation	1.5	1.6	1.5	1.6[4]	1.8	2.0	1.8	2.0	1.7	2.0	1.25[7]
SWR, max. attenuation	1.8	2.0	1.8	2.0	2.0	2.2	2.0	2.2	2.0	2.2	1.5[7]
Forward bias input resistance (ohms)	300	100	300	100	300	100	300	100	300	100	300
RF connector type	N	N	N	N	N	N	N	N	W/G[5]	W/G[5]	N
Weight, net lb (kg)	3 (1,4)	6 (2,7)	3 (1,4)	6 (2,7)	3 (1,4)	3 (1,4)	3 (1,4)	3 (1,4)	3 (1,4)	3 (1,4)	6 (2,7)
Shipping lb (kg)	4 (1,8)	9 (4,1)	4 (1,8)	9 (4,1)	4 (1,8)	5 (2,3)	4 (1,8)	5 (2,3)	4 (1,8)	5 (2,3)	9 (4,1)
Dimensions Length, in (mm)	11⅛ (283)	11⅜ (289)	11⅛ (283)	11⅜ (289)	8⅜ (213)	12½ (311)	8⅜ (213)	12¼ (311)	6¾ (171)	10½ (267)	11⅜ (289)
Width, in (mm)	3¼ (83)	4⅞ (124)	3¼ (83)	4⅞ (124)	3¼ (83)	3¼ (83)	3¼ (83)	3¼ (83)	3¼ (83)	3¼ (83)	4⅞ (124)
Height, in (mm)	2¼ (57)	2¼ (57)	2¼ (57)	2¼ (57)	2¼ (57)	2¼ (57)	2¼ (57)	2¼ (57)	2¼ (57)	2¼ (57)	2¼ (57)
Price	$450	$700	$450	$700	$450	$700	$450	$700	$450	$700	$700

Maximum ratings: maximum input power, peak or CW: 1 W; bias limits: −20 V, −10 V.
Bias polarity: negative voltage increases attenuation.
RFI: radiated leakage limits are below those specified in MIL-I-6181D at input levels less than 1 mW; at all input levels radiated interference is sufficiently low to obtain rated attenuation.

[1]With −5 V bias.
[2]4 dB, 4 to 4.5 GHz.
[3]Driven by HP 8403A Modulator.
[4]2.0 SWR, 4 to 4.5 GHz.
[5]Fits 1 x ½ in. (WR 90) waveguide.
[6]External high-pass filters required.
[7]Excluding high-pass filters.

SIGNAL GENERATOR ACCESSORIES
Additional capabilities for signal generation
Models 10511A, 10515A, 10514A, 10534A, 11507A-11509A



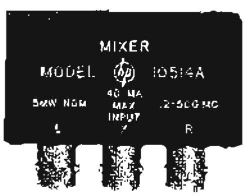
10511A

10511A Spectrum Generator

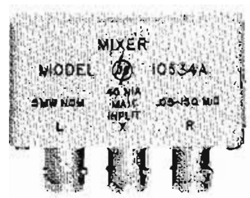
Extends the useful frequency range of signal generators, sources and frequency synthesizers by providing a spectrum of harmonics up to 1 GHz from sine-wave inputs between 10 and 75 MHz. A 50Ω bandpass filter can then be cascaded with the 10511A to extract the desired harmonic. The harmonic power available is at least −19 dBm for harmonics 1 thru 10.

Input requirements: 1 to 3 volts rms into 50Ω, 10 to 75 MHz.

Price: $200; shipping weight: ½ lb (0,23 kg)



10514A



10534A

10514A, 10534A Double Balanced Mixers

Used with signal generators in a variety of mixing as well as AM, pulse and square-wave modulation applications. The careful balancing of the hot carrier diodes in the 10514 and 10534 Mixers provides excellent suppression of the local oscillator and input frequencies at the output port. Frequency range of the 10514 is 0.2-500 MHz and the 10534 is 0.5-150 MHz. Both feature low conversion loss, low internal interference and good balance. "A" models are equipped with BNC female connectors.

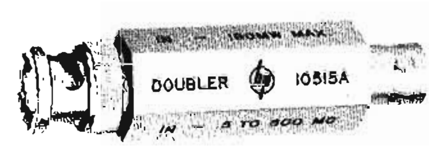
Shipping weight: 7 oz (198 g).

Price: HP 10514A, $90; HP 10534A, $70.

11508A Output Cable

Provides 50Ω termination and standard binding posts at the end of a 24-inch (610 mm) length of cable. Allows direct connection of the signal generator to high impedance circuits.

Price: $18; shipping weight: 1 lb (0,45 kg).



10515A

10515A Frequency Doubler

Extends the usable frequency range of signal generators, frequency synthesizers or other signal sources. Operating on input frequencies of 0.5 MHz to 500 MHz it provides a doubled output in the range of 1 MHz to 1 GHz. The frequency response of this 50Ω device is very flat (<±2 dB typically) over the entire frequency range and undesired harmonics are well suppressed.

Price: $150; shipping weight: ½ lb (0,23 kg).

11507A

11507A Output Termination

A multi-purpose termination which enhances the usefulness of the 606A or 606B by providing the following:

1. A matched 50-ohm termination to permit use into high impedance circuits.
2. A 20-dB (10:1) terminated voltage driver which reduces the source impedance to 5 ohms.
3. A dummy antenna having the IEEE standard characteristics for receiver measurements (driven from 10:1 divider).

Frequency range: 50 kHz to 65 MHz on 0 to 20 dB positions, 540 kHz to 23 MHz on dummy antenna.

Price: $70; shipping weight, 11 oz (311 g).

11509A

11509A Fuseholder

Prevents accidental burnout of attenuators in HP 606 and 608 Signal Generators during transceiver testing by introducing a fuse element between the signal generator and the transceiver. Several watts of RF power could otherwise be applied to the signal generator attenuator should the transceiver accidentally be switched to "Transmit." While the fuseholder provides protection, it in no way limits the usable output from the signal generators.

Accessories furnished: 10 extra fuses.

Price: $10; shipping weight: 13 oz (370 g).

SWEEP OSCILLATORS

Swept measurement

Swept frequency measurement is a method of characterizing magnitude and phase parameters as a function of frequency for an unknown device, component or system. A complete swept frequency measurement system has three basic elements: 1) a sweeper which is the signal source, 2) the unknown to be characterized and 3) the detector and display with which to interpret measurement results. Swept frequency measurements evolved as a fast, convenient and accurate method of phase and magnitude characterization replacing the laborious point by point measurement techniques.

The sweeper or signal source in a swept frequency system is a controlled oscillator which is made to vary in frequency between two limits in a prescribed manner, usually linear frequency change with time. The output power of the sweeper should be constant over the range of frequencies swept. Leveled power enables detection and displays to be presented accurately and directly without need for correction due to generator level change during sweep. Accurate frequency identifications depends on the sweeper's frequency accuracy, sweep width accuracy, sweep linearity and frequency stability with changes in temperature, load and line. Frequency accuracy is of prime importance in making narrow band measurements accurately and quickly using swept frequency techniques. Dynamic displays permit on-line adjustment and rapid testing of devices.

The output from the unknown must be detected and displayed in a manner which facilitates easy and accurate identification of sweep frequencies as well as magnitude and phase information. Several types of detectors-displays are available depending on application requirements.

For fast, inexpensive magnitude only measurements, the sweeper can be used in conjunction with the 8755 L/M Frequency Response Test Set. When accuracy and phase information are needed, the more sophisticated tracking detector or network analyzer is used with CRT displays. Hewlett-Packard CRT displays are available in two configurations: polar or magnitude-phase.

Sweep oscillators

The sweeper is a multipurpose test instrument used in the design, manufacture and maintenance of devices, components and systems. Hewlett-Packard sweepers cover the entire RF frequency spectrum from dc to 40 GHz in four broad instrument lines. These instruments feature solid state components to 18 GHz and plug-in versatility for a choice of band. Hewlett-Packard solid state and backward wave oscillator sweepers have superior frequency stability, high power output, external or internal modulation, analog and digital programming capability and systems compatibility.

Sweep oscillator features

Sweep range selection

The sweep frequency limits of the instrument may be set by selecting one of several different sweep modes. Start-Stop, Marker, Video, or Full sweep modes begin sweeping at one independently adjustable calibrated frequency and stop sweeping at a second independently adjustable calibrated frequency. With symmeterical or ΔF sweep, the center of the sweep range is first independently selected and then the calibrated sweep width is chosen. Manual sweep allows the sweeper to function with operator front panel control, a real convenience for calibration of display devices such as X-Y recorders.

Another valuable feature of today's solid state oscillators is self-contained, multiband capability in one compact instrument. This is the ability to select swept coverage from over six octave ranges. (i.e., from 100 MHz to 6.5 GHz) by simply pressing one band select lever, without expensive extraneous equipment.

Power output and leveling

Power out is adjustable at the front panel. To obtain constant power output and a good source match at microwave frequencies, an automatic leveling loop is employed. The basic external leveling configuration is shown in Figure 1 (internal leveling available as an option, if not standard, on all Hewlett-Packard sweep oscillators).

Leveling has two advantages:)1 leveled power output allows simplified detection and display and 2) the source match at the leveled output is markedly improved.

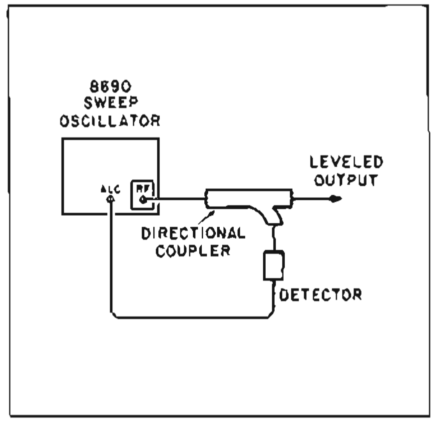


Figure 1. Basic closed-loop leveling system.

Modulation

Modulation capabilities further extend the sweepers usefulness both as a sweeper and as a signal generator for signal simulations. AM modulation is available both internally or externally on most Hewlett-Packard sweepers. AM modulation is useful for testing communication equipment and making microwave measurements (1 kHz modulation is required to drive the 415E SWR Meter). FM modulation allows remote analog programming of frequency (for example, for production testing) along with excellent FM signal simulation (for example, in communications).

Sweep control

Variable sweep rates are available from 0.01 to 3000 seconds to match characteristic detector-display responses. Sweep may be initiated with automatic trigger, external trigger or manual trigger. Frequency changes linearily with sweep time until reaching the end sweep frequency. Blanking and pen lift signals are available at rear output connectors during flyback time when the RF is off.

Digital Sweeping Synthesizers

Digitally Sweeping Synthesizers are the latest additions to Hewlett-Packard's Sweeper Product line. The 8660B and the 3330A/B combine the precision frequency accuracy and stability of a synthesizer with the time saving convenience of a sweeper. Parameters such as center frequency, frequency step, time per step number of steps and sweep width are entered through a convenient key board and are then executed by pressing a single button. Many of the 3330 sweep parameters can be changed which the instrument is sweeping. An additional feature provided by the 3330B is amplitude sweeping in steps as small as .01 dB. The amplitude can be stepped at the end of each frequency sweep cycle to produce a family of curves.

The major applications area for the 3330 lies in the stimulation of narrow band devices.

Sweeper applications

Swept frequency systems are used to characterize an unknown's phase and magnitude characteristics as a function of frequency. Two basic types of measurements are made: transmission characteristics and reflection characteristics. For many transmission type measurements, it is only necessary to know amplitude response and establish that the phase response is linear, thereby causing no phase distortion. Reflection measurements are used to optimize device for impedance matching in order to obtain maximum power transfer. Swept frequency techniques can give complete system characterization with S-parameter techniques for transistors, devices, components or systems.

For high power applications such as RFI-susceptibility test and high attenuation measurements, Hewlett-Packard offers TWT amplifiers which will provide better than 750 mW from 1-12.4 GHz. By phaselocking Hewlett-Packard's sweep oscillators, excellent microwave signal purity can be achieved for application such as microwave spectroscopy and high-Q swept frequency cavity measurements.

For achieving broadband sweep capability (more than one octave), Hewlett-Packard offers the HP 8707A RF Unit Holder and 8706A Control Unit. The 8706A Control Unit is placed in the sweeper and the RF plug-ins placed in the 8707A RF Unit Holder. Control of up to seven RF plug-ins is possible. With Hewlett-Packard's new solid state microwave sweepers, the 8620 series, this multiband capability is built-in and thus can operate as a value packed stand-alone instrument.

Complete amplitude and phase description of microwave devices is a powerful tool for component and systems design and test. Hewlett-Packard sweeper/network analyzer systems provide metered or CRT type (polar or magnitude and phase) real time display of this information. Active microwave components in a variety of packages, including can and stripline, can be accurately characterized and tested to 12.4 GHz.

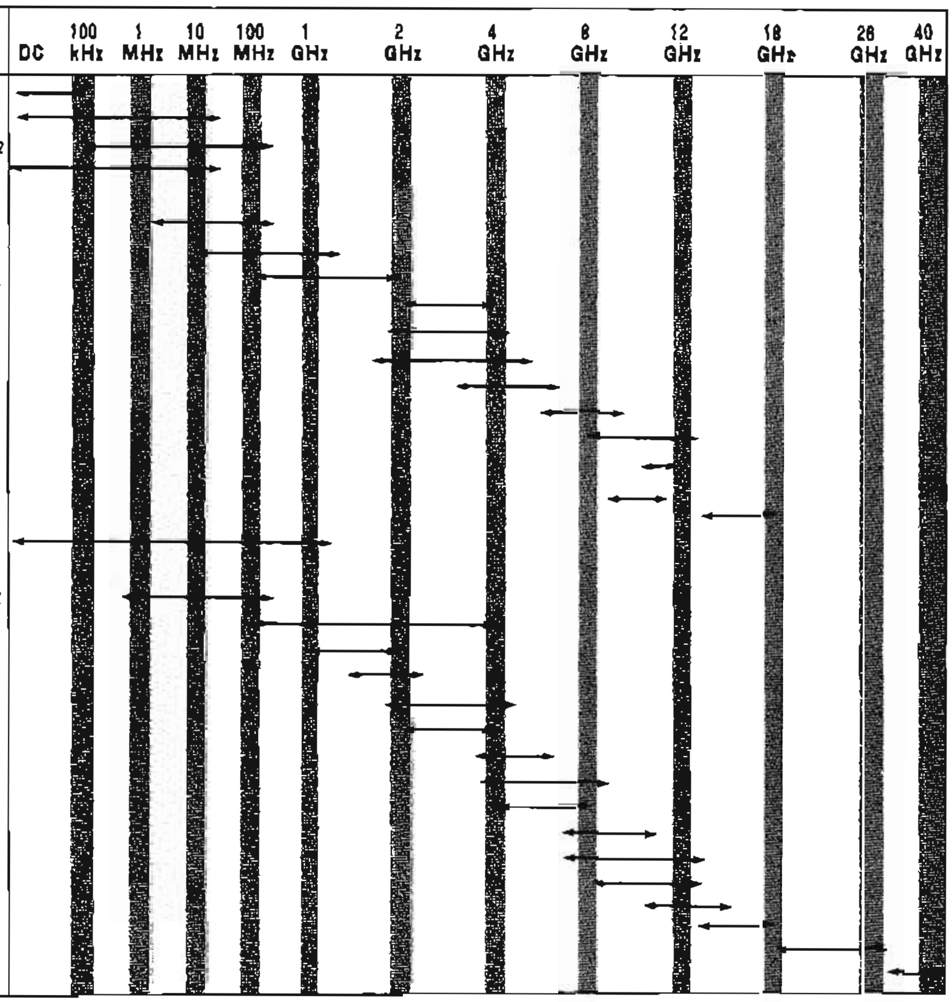
Several Hewlett-Packard application notes such as the following describe numerous swept frequency measurements:

- AN65, "Swept Frequency Techniques"
- AN95, "S-Parameters . . . Circuit Analysis and Design"
- AN117-1 "Microwave Network Analysis Applications"
- AN117-2 "Stripline Component Measurements", etc.

All of these notes and others are available from your local Hewlett-Packard sales office.

Hewlett-Packard Sweep Oscillator—Summary Chart

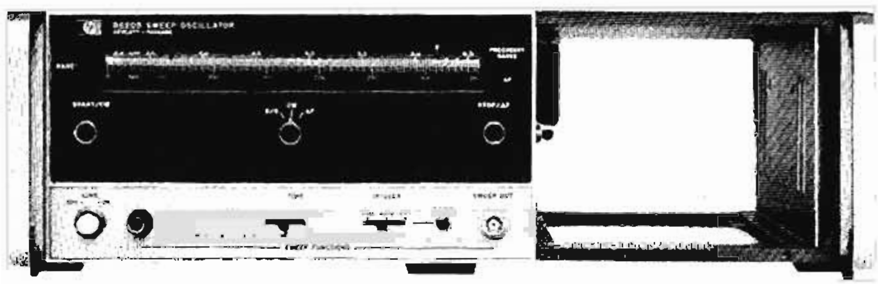
Model Number	Page No.	Frequency Range
3304A-3305A	(321)	DC-100 kHz
675A	(413)	10 kHz-32 MHz
8601A	(368)	100 kHz-110 MHz
3330A/B	(330)	0.1 Hz-13 MHz
8620 Series	(359)	
86210A		3-350 MHz
86220A		10-1300 MHz
86320A		100 MHz-2.0 GHz
86230A		2.0-4.0 GHz
86230B-86330A		1.8-4.2 GHz
86331A		1.7-4.3 GHz
86241A/B-86341B		3.2-6.5 GHz
86242A-86342A		5.9-9.0 GHz
86250A/B-86350A		8.0-12.4 GHz
86351A		10.7-11.7 GHz
86352A		8.5-10.5 GHz
86260A		12.4-18.0 GHz
8660B	(342)	0.01-1300 MHz
8690 Series	(364)	
8698B		400 kHz-110 MHz
8699B		100 MHz-4.0 GHz
8691A/B		1.0-2.0 GHz
8691A opt. 200		1.4-2.5 GHz
8692B opt. 100		1.7-4.2 GHz
8692A/B		2.0-4.0 GHz
8693A opt 200		3.5-6.75 GHz
8693B opt. 100		3.7-8.3 GHz
8693A/B		4.0-8.0 GHz
8694A/B opt. 200		7.0-11.0 GHz
8694A/B opt. 100		7.0-12.4 GHz
8694A/B		8.0-12.4 GHz
8695A opt. 100		10.0-15.5 GHz
8695A/B		12.4-18.0 GHz
8696A		18.0-26.5 GHz
8697A		26.5-40.0 GHz



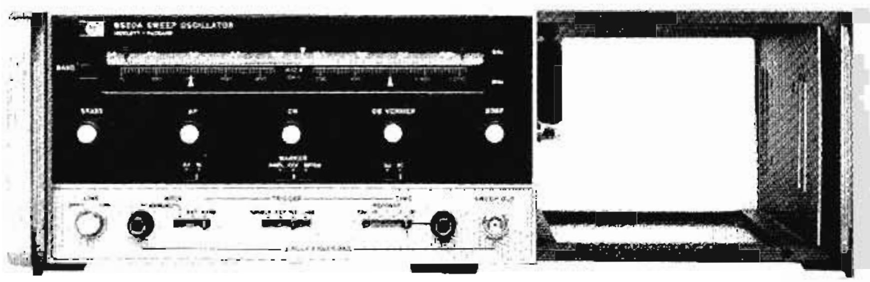
VALUE FAMILY OF SWEEP OSCILLATORS
Models 8620A/B, 8621A, 86200 Series, 86300 Series

A Solid State Sweeper System with Outstanding Performance, Extreme Flexibility of Configurations, and Attractive Economies . . . All Made Possible by Modular Construction and Development of Superior Microelectronic Components.

The Mainframes:



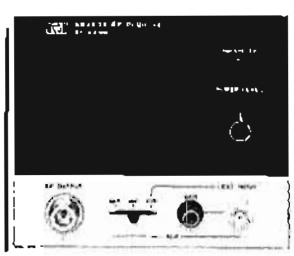
8620B



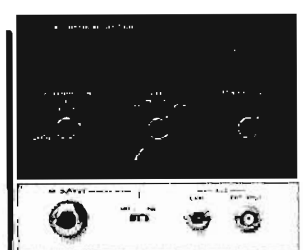
8620A

The RF Plug-ins:

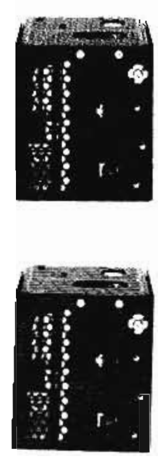
Single-band or Multi-band



86200 Series
3 MHz to 18.0 GHz



NEW
8621B
RF Drawer



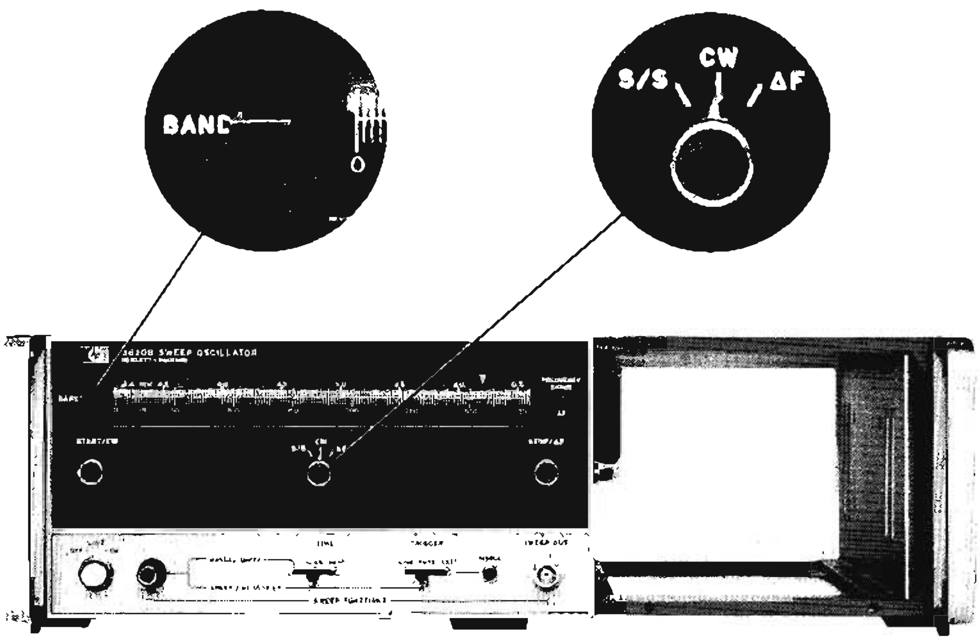
86300 Series
RF Modules
100 MHz to 12.4 GHz

A choice of two Solid State Mainframes
Models 8620B, 8620A

The 8620 family of sweep oscillators offers a choice of two solid state mainframes. Both are completely compatible with all RF plug-ins and offer as a standard feature multiband capability. The two mainframes differ in the number of operating modes and price.

Frequency band is selected by pressing a lever that rotates the frequency dial. This feature is standard on the 8620B as well as the 8620A mainframe.

One Simple Control allows setting of a CW frequency or Start-Stop sweep or ΔF sweep. This simplicity in the 8620B mainframe provides a high value sweeper at an extraordinarily low price.



8620B

The 8620B is the more economical of the two mainframes but has all the features normally needed for swept-frequency measurements. It has highly linear sweeps, wide and narrow, and a stable CW. Yet it is priced much lower than any similar sweeper on the market.

Dimensions: 5¼" (133 mm) high, 13¼" (337 mm) deep, 16¾" (425 mm) wide.

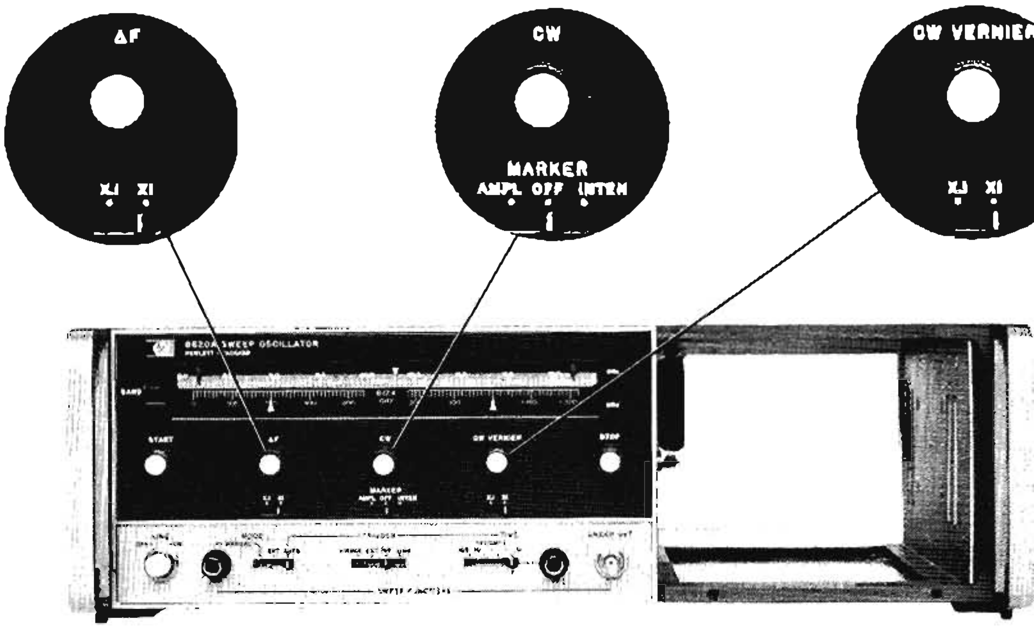
Weight: net, 24 lbs (11,1 kg); shipping, 30 lbs (13,4 kg).

Price: $1025.

ΔF Control sets a continuously calibrated sweep centered about the CW control setting. The expand switch allows frequency calibration from either 0 to 10% or 1% of full frequency band.

Independent CW Control serves as an amplitude or intensity marker when sweeping in the start-stop mode.

CW Vernier gives better frequency resolution than would be available on a 20-inch dial scale. This allows precise settings of CW frequencies or ΔF center frequencies.



8620A

The 8620A offers all that the 8620B offers, and in addition has many other features that are highly useful in more stringent applications. Push-button convenience provides great latitude of control along with exceptional frequency resolution and settability. This mainframe can also be a completely programmable source (Option 001). Yet this mainframe is priced surprisingly low.

Dimensions: 5¼″ (133 mm) high, 13¼″ (337 mm) deep, 16¾″ (425 mm) wide.

Weight: net, 24 lbs (11,1 kg); shipping, 30 lbs (13,4 kg).

Price: $1500.

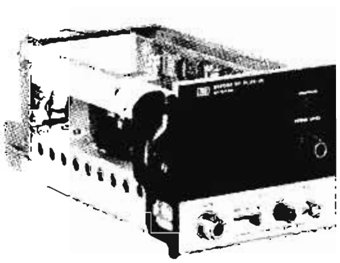
Option 001: add $500.

A choice of two types of RF Plug-ins

86200 Series, 86300 Series

SINGLE BAND Plug-ins

• High Performance • Low Cost



86200 Series

The 86200 series single-band plug-ins make extensive use of microelectronics for superior performance and high reliability at an extremely low price. Fundamental oscillators are either YIG-tuned transistor or bulk-effect circuits. YIG tuning results in exceptional tuning linearity and assures low noise and low spurious content. YIG tuning also provides low distortion frequency modulation capability at several MHz deviations and several MHz rates. Microcircuit PIN modulators in the plug-ins provide RF level control and amplitude modulation with virtually no frequency pulling.

The 86200 series plug-ins are completely compatible with either the 8620A or 8620B mainframe. Standard plug-ins are listed below. Special frequency bands and higher power outputs are available on request.

86200 Series Options

Option 001 internal leveling, not available on 86260A, add $375.

Option 002: 70 dB attenuator in 10 dB steps available in 86210A and 86220A, add $150.

Option 004 rear RF output, add $75.

Option 005: APC-7 RF output connector available on 86260A, add $35.

86200 Series RF Plug-ins

Frequency Range (GHz)	Maximum Leveled Pwr (dBm)	Spurious: Harmonics/ Nonharmonics (−dB)	Residual FM kHz peak)	Model Number	Price
0.003–0.35	13	30/70	<5	86210A[1]	$1,375
0.01–1.3	10	25/40	<5	86220A[1]	1,775
2.0–4.0	7	16/60	<7	86230A	1,500
1.8–4.2	10	20/60	<7	86230B	1,900
3.2–6.5	4	20/60	<7	86241A	1,575
5.9–9.0	8	30/60	<15	86242A	1,805
8.0–12.4	5	30/60	<15	86250A	1,775
8.0–12.4	8	30/60	<15	86250B	2,100
12.4–18.0	7	25/50	<25	86260A	2,950

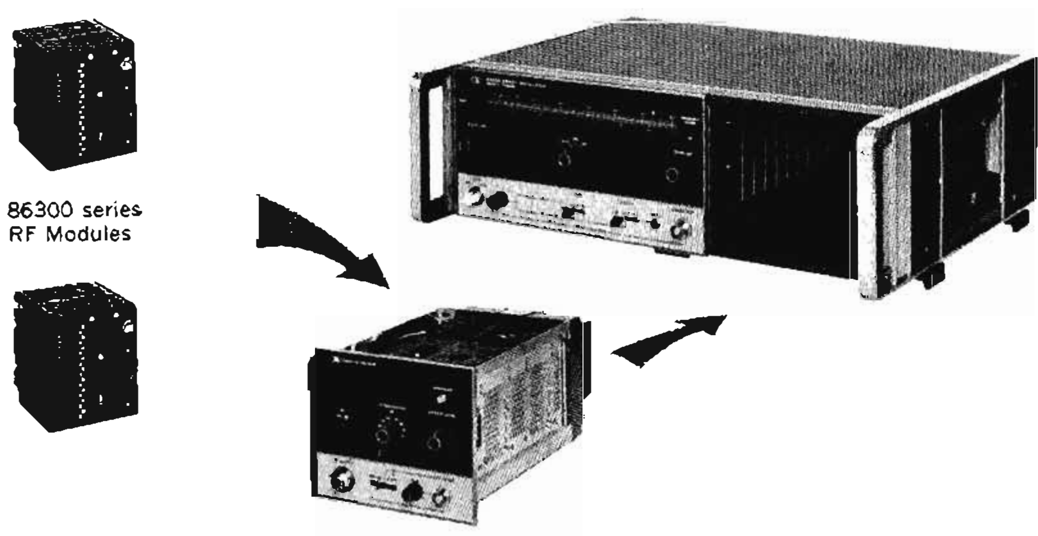
[1] Standard internal leveling and calibrated power output.

Dimensions: 5″ (127 mm) high, 11⅝″ (295 mm) deep, 6″ (152 mm) wide.

Weight: net, 5 lbs (2,3 kg); shipping, 7 lbs (3,2 kg).

MULTIBAND Plug-ins

- Modular Construction
- Self-contained



86300 series RF Modules

8621B RF Drawer

86300 Series RF Modules

Frequency Range (GHz)	Maximum Leveled Pwr (dBm)	Spurious: Harmonics/ Nonharmonics (−dB)	Residual FM kHz peak	Model Number	Price
0.1-2*	+13	30/30	<15	86320A	$1,750
1.8-4.2	+10	20/60	<7	86330A	1,850
1.7-4.3	+8	20/60	<7	86331A	2,100
3.2-6.5	+10	20/60	<7	86341B	1,850
5.9-9.0	+7	30/60	<15	86342A	2,000
8.0-12.4	+6	30/60	<15	86350A	2,000
8.5-10.5	+10	30/60	<15	86352A	1,850
10.7-11.7	+10	30/60	<15	86351A	1,750

*86320A heterodyne module must only be used with 86330A or 86331A. It cannot be used alone or with any other modules.

8621B RF Drawer, price: $425.
- Option 100—Multiband capability, add $400.
- Option 010—70 dB attenuator, add $650.
- Option 004—Rear RF output, add $75.
- Dimensions: 5" (127 mm) high, 11⅝" (295 mm) deep, 6" (152 mm) wide.
- Weight: net, 3 lbs (1,4 kg); shipping, 5 lbs (2,3 kg).

86300 Series Options
- Option 030 includes 8690B dial scale, no charge.
- Option 001 internal leveling, add approximately $250.
- Dimensions: 4" (103 mm) high, 3¾" (95 mm) deep, 3⅝" (92 mm) wide.
- Weight: net, 3 lbs (1,4 kg), shipping, 4 lbs (1,8 kg).

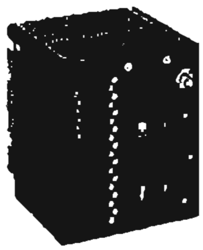
With a multiband plug-in, changing frequency bands is as simple as pressing a front panel lever. Modular construction of a multiband plug-in allows a choice of any two fundamental RF modules and a heterodyne module. For example, 0.1 to 6.5 GHz can be covered in one self-contained plug-in. All switching necessary to multiplex the desired frequency band to a single output port is included in the plug-in.

The multiband plug-ins consist of two basic parts: the 86300 series RF Modules and the 8621B RF Drawer.

The 86300 series RF Modules contain all of the microelectronic components that determine frequency range and power output. These microcircuits, in addition to giving the high performance and reliability that is normally expected of solid state components, are small enough so that a complete source module occupies only about four inch cube. These same modules can be used in conjunction with the 8700A RF Drawer to provide solid state plug-ins for the 8690A and 8690B mainframes.

The 8621B RF Drawer houses the 86300 series RF Modules. The standard drawer will accept one fundamental oscillator module. However, with the 1.8 to 4.2 GHz fundamental oscillator module, the standard drawer also accepts the 0.1 to 2 GHz heterodyne module to give 0.1 to 4.2 GHz coverage. The 8621B Option 100 will accept two fundamental oscillator modules and the heterodyne module. An optional 70 dB attenuator is also available along with a choice of either front or rear RF output.

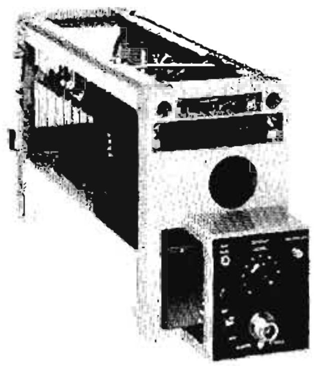
SOLID STATE RF MODULES ...FOR 8690 SWEEPER SERIES



86300 Series RF Module. Same solid state modules as used in 8620 family of Sweep Oscillators.

The familiar 8690 BWO Sweeper product line now has reliable solid state plug-ins up to 12.4 GHz. The 8700A RF Drawer in conjunction with any one of the 86300 series RF modules makes a complete RF plug-in for the 8690A or 8690B mainframe. Expensive and annoying BWO replacements are no longer necessary. In fact, the low price of these solid state plug-ins makes it more economical in the long run to buy an 8700A plus an RF module rather than replacing an expired BWO.

A complete solid state plug-in is specified by ordering an 8700A and one of the RF modules listed on page 363.



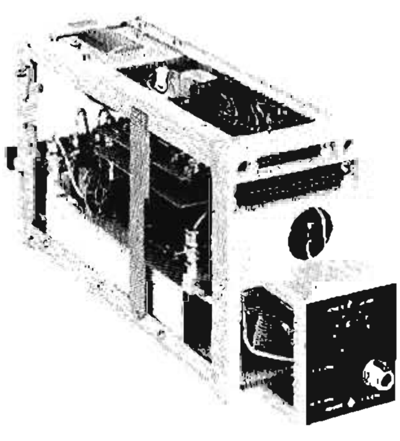
8700A RF Drawer

Dimensions: 4½" wide, 7¼" high, 17½" deep (115 mm x 185 mm x 445 mm).
Weight: net, 9 lbs (4,1 kg); shipping, 12 lbs (5,5 kg).
Price: $425.

8690B Sweep Oscillator Mainframe

The 8690B Sweep Oscillator offers exceptional value in performance, operation and versatility. The 8690B mainframe provides complete flexibility with start/stop, ΔF, and marker sweep along with CW operation and AM and FM capability. The complete family of solid state and BWO plug-ins shown below, accent this value with coverage from 400 kHz to 40 GHz.

Dimensions: 8¾" (222 mm) high, 18⅜" (467 mm) deep, 16¾" (425 mm) wide.
Weight: net, 49 lbs (22,2 kg); shipping, 59 lbs (26,8 kg).
Price: $1700.



8699B RF Plug-in

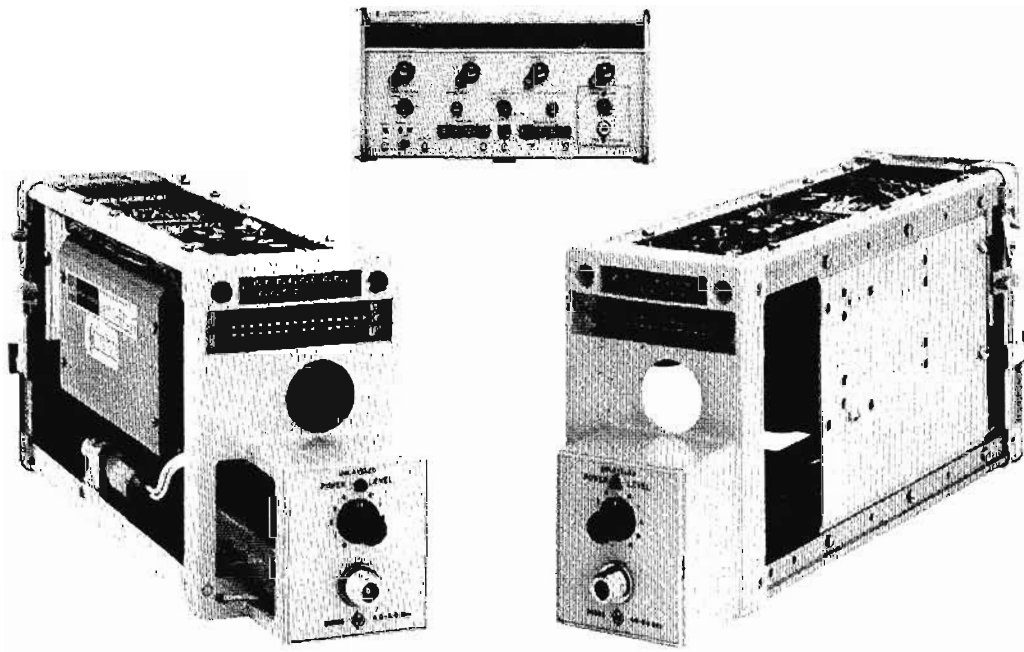
PIN Leveled Solid State RF Plug-ins

Long life and high reliability are key features of all solid state oscillators. Through the extensive use of microelectronic circuitry such as absorptive PIN modulators, excellent performance is achieved in the areas of wide frequency coverage, low frequency pulling, low residual FM and good source match impedance.

Frequency Range (GHz)	Maximum Leveled Power	Harmonics/ Spurious (−dB)	Residual FM (kHz peak)	Price	Model Number
400 kHz to 110 MHz	>20 mW	20/40	<.5	$1,625	8698B
0.1-4.0	> 6 mW	20/40	<3	3,750	8699B

BWO RF PLUG-INS

For high power and high frequency applications
8690 Series



8693A 8693B

Grid Leveled BWO RF Plug-ins

Grid leveled BWO's achieve power and leveling control by changing bias on the grid of the BWO. Grid leveling provides the highest RF power plug-ins since no additional components such as PIN modulators are necessary for power control.

Frequency Range (GHz)	Maximum Leveled Power	Spurious: Harmonics/ Nonharmonics (-dB)	Residual FM (kHz peak)	Model Number	Price
1.0-2.0	>100 mW[1]	20/40	<30	8691A	$2,295
1.4-2.5	>100 mW	20/40	<30	8691A/ Opt. 200	2,545
2.0-4.0	>70 mW[1]	20/40	<30	8692A	2,105
3.5-6.75	>40 mW	20/40	<50	8693A/ Opt. 200	2,475
4.0-8.0	>25 mW[1]	20/40	<50	8693A	1,850
7.0-11.0	>25 mW[1]	20/40	<60	8694A/ Opt. 200	1,900
7.0-12.4	>25 mW[1]	20/40	<60	8694A/ Opt. 100	2,150
8.0-12.4	>50 mW[1]	20/40	<60	8694A	1,850
10.0-15.5	>25 mW	20/40	<150	8695A/ Opt. 100	3,075
12.4-18	>40 mW	20/40	<150	8695A	1,975
18-26.5	>10 mW	20/40	<200	8696A	2,750
26.5-40	>5 mW	20/40	<350	8697A	4,500

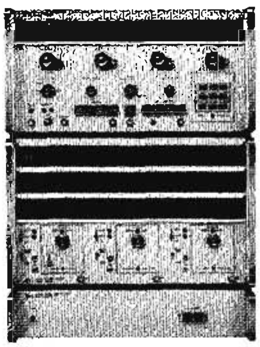
1. Option 001 internal leveling available.
Option 004, rear RF output available except on 8695A opt. 100

PIN Leveled BWO RF Plug-ins

PIN leveled BWO's achieve power and leveling control with a PIN modulator placed between the BWO and the front panel RF output. With constant bias and load impedance, the BWO provides a signal with low residual FM and frequency pulling with changes in power levels or load.

Frequency Range (GHz)	Maximum Leveled Power	Spurious: Harmonics/ Nonharmonics (-dB)	Residual FM (kHz peak)	Model Number	Price
0.0004-0.11	20 mW	30/35	<5	8698B[2]	$1,625
0.1-4.0	6.5 mW	25/30	<15	8699B[2]	3,750
1.0-2.0	>70 mW	20/40	<10	8691B	2,670
1.7-4.2	>15 mW	20/40	<20	8692B/ Opt. 100	2,805
2.0-4.0	>40 mW	20/40	<15	8692B	2,455
3.7-8.3	>5 mW[1]	20/40	<20	8693B/ Opt. 100	2,550
4.0-8.0	>15 mW[1]	20/40	<15	8693B	2,225
7.0-11.0	>15 mW	20/40	<20	8694B/ Opt. 200	2,300
7.0-12.4	>15 mW[1]	20/40	<20	8694B/ Opt. 100	2,550
8.0-12.5	>30 mW[1]	20/40	<15	8694B	2,250
12.4-18	>15 mW	20/40	<40	8695B	2,475

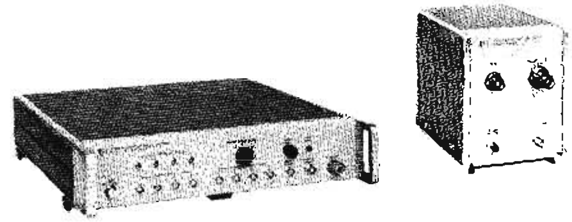
1. Option 001 internal leveling available. 2. Solid state plug-in.
Option 004, rear RF output available on all models



8690B with 8706A Control Unit

8707A RF Unit Holder with 8690B RF Units

8705A Signal Multiplexer



8701A 8404A

Multiband systems

Broadband sweep capability, 400 kHz to 40 GHz, with pushbutton control of frequency range is available with the 8706A Control Unit and the 8707A RF Unit Holder. The 8706A Control Unit plugs into the 8690B in place of the normal 8690B RF plug-in and the 8707A RF Unit Holder accepts the 8690B RF plug-ins which are to be controlled. It is possible to have pushbutton control of from two to seven 8690B RF plug-ins with an 8706A Control Unit and from one to three 8707A Unit Holders.

The 8705A Signal Multiplexer switches RF signals up to 12.4 GHz from three 8690B-series RF units to either of two RF ports. To provide leveled power at the 8705A RF output ports, a detector operating from a wideband coupler in the 8705A provides an ALC signal for the 8690B Sweep Oscillator leveling circuits.

Specifications, 8705A

Frequency range: dc to 12.4 GHz. Output port reflection coefficient ≤0.25 (VSWR ≤1.67). Input port reflection coefficient ≤0.15 (VSWR ≤1.35).

Insertion loss: 3 dB.

Weight: net, 17 lbs (7,8 kg); shipping, 22 lbs (10 kg).

Price: Model 8705A, $2075.

Specifications, 8706A

Compatibility: the 8706A controls up to three 8707A RF Unit Holders; Option H26 for remote band switching of 8699B.

Weight: net, 16 lbs (7,3 kg); shipping, 25 lbs (11,4 kg).

Price: Model 8706A, $650.

Specifications, 8707A

Capability: accepts up to three 8690B RF units.

Frequency range: 400 kHz to 40 GHz.

Sweep functions

Normal: permits all 8690B sweep functions.

Preset: provides start-stop sweep determined by preset adjustments on the 8707A. Sweep end points can be set independently for each RF unit.

Weight: net, 30 lbs (13,6 kg); shipping, 37 lbs (16,8 kg).

Price: Model 8707A, $1525.

8701A Sequential Sweep Control

The 8701A Sequential Sweep Control makes possible wideband sweeping by sequentially triggering and controlling two, three, or four 8690A/B or 690C/D Sweeper Mainframes.

When the sweepers are connected to the 8701A, they maintain all of their sweep functions (i.e., START/STOP, $\triangle$F, and MARKER SWEEP) and capabilities (sweep time and band tuning). Thus, a set of sweeper mainframes can operate in the START/STOP function to provide wideband sweeping, or one or more sweepers can operate in $\triangle$F or MARKER SWEEP function to provide narrowband sweeping. Switching from wideband to narrowband sweeping is accomplished with the ease of pushing a button. Furthermore, by setting band ends for each sweeper mainframe independently, one can sweep any special band of interest such as communications and ECM bands which are not normally available in one RF plug-in oscillator.

Specifications, 8701A

Frequency coverage: 1-12.4 GHz; 1-18 GHz (8701A Option 001).

Leveling: $<\pm1.5$ dB (1-2 GHz); $<\pm1.25$ dB (2-12.4 GHz); $<\pm2$ dB (12.4-18 GHz).

Weight: net, 16 lbs (7,3 kg); shipping, 20 lbs (9,1 kg).

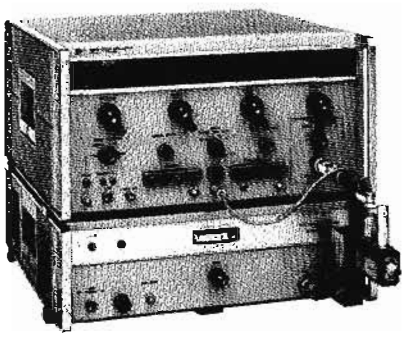
Dimensions: 16¾" wide, 3-25/32" high, 18⅜" deep (425 x 96 x 467 mm).

Price: 8701A, $3850; Option 001, add $200.

8404A Power Meter Leveling Amplifier

The 8404A Leveling Amplifier is used to level the 8690B Sweeper when a power meter is used as the RF detector. When the recorder output of the power meter (431B/C or 432A/B/C) is connected to the 8404A Leveling Amplifier and the output of the 8404A is connected to the external AM input of the 8690B, ±0.05 dB or less variation in leveled output can be expected.

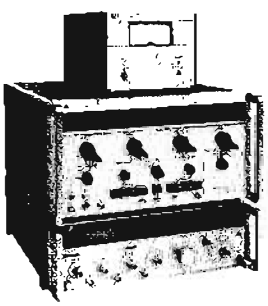
Price: Model 8404A, $395.



Leveled High-power Sweep Oscillator Systems

Leveled High-Power Sweep Oscillators

The E15-8690A/B Series leveled high-power sweep oscillator systems provide 750 mW broadband or 1 watt narrow band in four bands from 1 GHz to 12.4 GHz. Flatness is ±0.3 dB from 1.0 to 8.0 GHz and ±1.0 dB from 8.0 to 12.4 GHz. These systems are complete with solid state or BWO sweeper, Hewlett-Packard traveling wave amplifier, band-pass filter (8430A Series), directional detector (780 Series) and needed cables.



(8709A Synchronizer)

8320A Stabilized Source

8320A, 8321A, and 8324A Stabilized Sweep Oscillator Systems

Stabilized Sweep Oscillator Systems are phase-locked systems which increase the frequency stability of the microwave sweeper for more sophisticated microwave applications such as narrow-band receiver or filter tests, parametric amplifier pumps or Doppler system sources. Other applications include reflectometers, microwave spectroscopy and radio astronomy. CW stabilized systems are available from .1 to 40 GHz.

Complete specifications or data on these systems is available on request from Hewlett-Packard. Stabilized swept systems are available on special order.

Selected Specifications

Stabilized mode: CW only.

Frequency range: 0.5-12.4 GHz (8320A); 12.4-40 GHz Waveguide (8321A); 0.5-12.4 GHz (8324A).

Stability: $\leq 5 \times 10^{-8}$/hr.

Residual FM: $\leq 2 \times 10^{-7}$ in 20 Hz-15 kHz audio bandwidth.

Dimensions: 15" high, 19" wide, 18" deep (approximately).

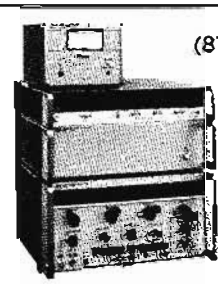
Price: $7,500 to $16,000 depending on band.

11531A

11531A Test Unit

The Model 11531A Test Unit facilitates 8690B Sweep Oscillator calibration. The unit plugs into the 8690B like an RF unit. Calibration voltages for sweep range amplitude and end points (all sweep modes) as well as marker calibration, BWO calibration, Blanking and Pen lift are sampled and made available at the Model 11531A front panel output for fast, accurate calibration.

Price: Model 11531A, $400.



(8709A Synchronizer)

8475A Microwave Synthesizer Signal Source

8457A Microwave Synthesizer, 8-40 GHz

The 8457A Programmable Microwave Synthesizer System offers today's user the utmost in frequency stability, operating simplicity and systems compatibility. Typical areas of application include automatic test systems, CW/Doppler radar, telecommunications, secure communications, narrow-band filter and receiver testing, anechoic chamber evaluations, radio and radar astronomy, MRR and EPR analytical spectroscopy. Complete specifications and options available on request.

Price: Model 8457A, $26,300 to $32,300 depending on frequency range and options ordered.

8709A Synchronizer

The 8709A Synchronizer features automatic synchronization and side-band cancellation; the lock points are spaced by the reference oscillator frequency (240-400 MHz). This eliminates ambiguities in achieving phase-lock and identifying harmonic lock numbers.

8709A Specifications

Input frequency: 20 MHz.

Sensitivity: −65 dBm.

Minimum output voltage

High level: +12.0 to −12.0 V dc.

Low level: +0.8 to −0.8 V dc.

Weight: net, 12 lbs (5,4 kg); shipping, 15 lbs (6,8 kg).

Price: HP 8709A, $995.

GENERATOR/SWEEPER
Digital marker
Model 8601A, 8600A

8601A

Covering 100 KHz to 110 MHz, the Model 8601A Generator/Sweeper combines the high linearity and flatness of a precision sweeper with a signal generator's frequency accuracy and wide range of calibrated power levels. Though it's small and lightweight, it does the work of two instruments easily and conveniently.

Specifications, 8601A

Frequency range: low range, 0.1-11 MHz; high range, 1-110 MHz.

Frequency accuracy: approximately ±1% of frequency.

Power output: +20 to −110 dBm; 10-dB steps and 13-dB vernier provide continuous settings over entire range. Meter monitors output in dBm and rms volts into 50Ω.

Power accuracy: ±1 dB accuracy for any output level from +13 dBm to −110 dBm.

Flatness: ±0.25 dB over full range, ±0.1 dB over any 10 MHz portion (+10 dBm step or below).

Impedance: 50Ω, SWR <1.2 on 0 dBm step and below.

Harmonics and spurious signals: (CW above 250 kHz, output levels below +10 dBm) harmonics at least 35 dB below carrier. Spurious at least 40 dB below carrier.

Residual FM: noise in a 10 kHz bandwidth including line related components (dominant component of residual FM is noise).

CW: less than 50 Hz rms, low range; 50 Hz rms high range.

SYM 0, sweep: less than 100 Hz rms, low range; 1 kHz rms, high range.

Residual AM: AM noise modulation index (rms, 10 kHz bandwidth) is <−50 dB; (typically −60 dB at 25°C).

Crystal calibrator: internal 5-MHz crystal allows frequency calibration to ±10% at any multiple of 5 MHz.

Sweep modes: full, video, and symmetrical.

Internal AM: fixed 30% ±5% at 1 kHz.

External AM: 0 to 50%, dc to 400 Hz; 0 to 30%, up to 1 kHz.

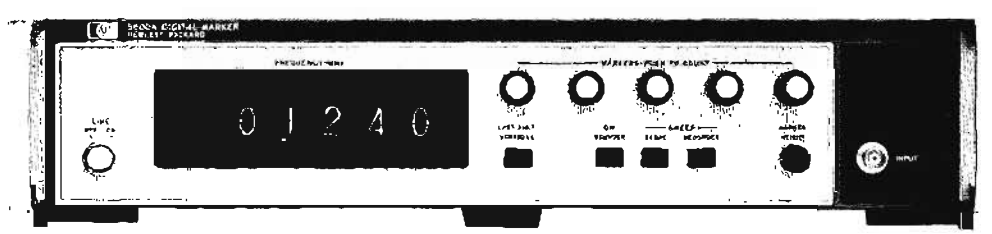
Internal FM: 1 kHz rate, fixed 75 kHz ±5% deviation, high range; 7.5 kHz ±5% deviation, low range; <3% distortion.

External FM: sensitivity, 5 MHz per volt ±5%, high range; 0.5 MHz per volt ±5%, low range; negative polarity; FM rates to 10 kHz.

Weight: net, 21 lb (9,5 kg); shipping 27 lb (12,3 kg).

Dimensions: 7 25/32" wide, 6 3/32" high, 16 3/8" deep (190 x 155 x 416 mm).

Price: Model 8601A, $2250.



8600A

The Model 8600A Digital Marker provides five independent, continuously variable frequency markers over the range 0.1-110 MHz when used with the HP 8601A or 8690B/8698B Generator/Sweeper.

The high resolution controls and 6-digit readout permit 0.05% frequency settability. The frequency of any marker may be read while sweeping, simply by pushing a button within the marker control. The marker selected is brighter than the others and points in the opposite direction, ensuring positive marker identification.

Specifications, 8600A

Marker accuracy: any marker may be placed at a desired frequency ± (0.05% of sweep width + 8601A sweeper stability).

Weight: net, 13 lbs (5,9 kg); shipping, 18 lbs (8,2 kg).

Dimensions: 3⅞" high, 16¾" wide, 13¼" long (99 x 413 x 337 mm).

Price: Model 8600A, $1100.

Option 001: includes modif. kit for 8690B/8698B; no additional charge.

Power measurements

At microwave frequencies, power is the basic measure of signal amplitude. Unlike voltage and current, microwave power remains constant along a lossless transmission line. Thermocouple and thermistor power meters are the most common type of instruments used to measure microwave power.

Thermocouple power meters

The use of thermocouples as a sensing element is the most recent development in microwave power measurement. Wide range, low drift, and simple operation are the major advantages of thermocouples over other detectors.

A thermocouple measurement system consists of a power sensor which produces a dc output voltage proportional to the power dissipated in it and a power measurement circuit which measures the dc voltage and displays it in units of power.

The power sensor provides an impedance match between the thermocouple element and the microwave transmission line. In the Hewlett-Packard 8481A Power Sensor, input power is dissipated in silicon-tantalum nitride thermocouple elements. The dissipated power causes the junction temperatures to rise above the ambient temperature of the sensor substrate. This temperature differential and resulting thermocouple voltage are proportional to the applied power. The small physical size of the element and careful design of the structure assure that changes in ambient temperature affect all junctions equally, thus making the system relatively insensitive to zero drift.

The dc output voltage is amplified by an FET, chopper-stabilized amplifier in the power sensor and delivered to the power meter.

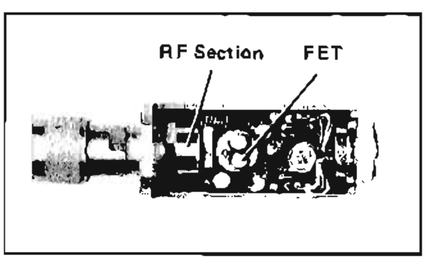


Figure 1.

With thermocouple type power meters, accuracy is fundamentally dependent on the instrument's gain being matched to the power sensor sensitivity. Since thermocouple sensitivity is subject to change with variations in temperature, overload, and aging, a convenient means of calibration is vital.

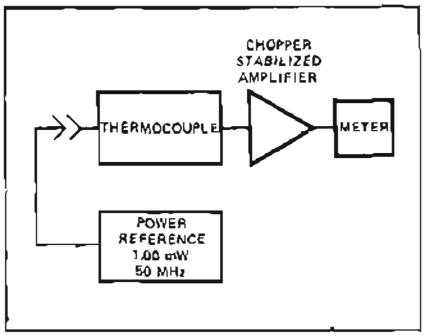


Figure 2

The Hewlett-Packard 435A Power Meter provides an accurate, built-in power reference for use in calibrating the meter-power sensor combination. In this way, long term accuracy is assured. With the 8481A Power Sensor, the meter measures power from 0.3 μW to 100 mW at frequencies from 5 MHz to 18 GHz.

Thermistor power meters

Thermistors offer an alternative means to measure microwave power. A thermistor is a resistive element whose resistance decreases with increasing temperature. In a thermistor type instrument, the sensor elements are contained in a mount and form one leg of a Wheatstone bridge through a bias connection to the power meter. DC or ac excitation biases the thermistor elements to balance the bridge. When microwave power is applied to the sensor elements, the resulting temperature rise causes the thermistor resistance to fall, unbalancing the bridge. Withdrawing an equal amount of bias power from the thermistors rebalances the bridge. The change in bias power is then measured and displayed on a meter.

Automatic thermistor bridges

There are a number of thermistor bridge designs which provide various degrees of accuracy, speed, and convenience.

The Hewlett-Packard 432-series of Power Meters use a temperature-compensated, automatically balanced bridge of versatile design. Operating with any of the Hewlett-Packard temperature-compensated thermistor mounts, the meter automatically maintains bridge balance and reads substituted bias power over ranges of 10 microwatts to 10 milliwatts (full scale).

Since thermistor elements are temperature-sensing devices, they are unable to distinguish between applied power level changes and environmental temperature changes. As thermistor bridge sensitivity is increased, even minute temperature variations can unbalance the bridge. This results, if uncompensated, in "zero drift" of the power meter and erroneous power measurements.

A dual bridge arrangement, as shown in Figure 3, is used in the 432-series to compensate for variations in temperature at the thermistor mount. The thermistor mounts used have two thermistor elements. The two are in close thermal proximity and are affected equally by changes in ambient temperature. Thus R_D responds to both ambient temperature and applied RF power; R_C, isolated from the RF power, responds only to ambient temperature. Each element is connected to its own bridge circuit in the power meter which automatically controls bias

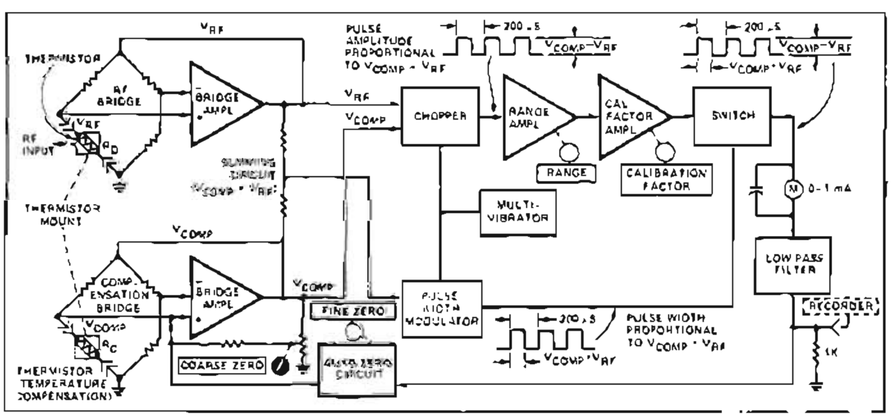


Figure 3. Block diagram of HP 432A Power Meter. Dual bridge provides proper bias to thermistor mount to correct for temperature variation and reduce zero drift.

power. This arrangement compensates for temperature changes, thus reducing zero drift by a factor of 100 over uncompensated thermistor meters. Another advantage of this design is that when zeroed on the most sensitive range, the meter may be switched to any other power range without rezeroing (zero-carryover is within ±0.5% on all ranges). A dc output proportional to the meter deflection is available for recording purposes or control of external circuits such as power meter levelling of microwave sweep oscillators and signal generators.

Compensated thermistor mounts available for the 432-series of power meters include the 478A (10 MHz to 10 GHz) and the 8478B (10 MHz to 18 GHz) coaxial mounts. The 486A Waveguide Series collectively cover the waveguide bands from 2.6 to 40 GHz. All mounts have low SWR over their frequency ranges without tuning.

Peak power measurement

A frequent requirement in microwave work is the measurement of peak power in a periodic pulse. This may be done by various indirect techniques using thermocouples or thermistors. Hewlett-Packard produces a versatile instrument that conveniently measures peak power directly in the 50 MHz to 2 GHz frequency range. This instrument (the model 8900B) utilizes a video comparator technique to bring a known dc voltage, supplied by the instrument, in a known impedance to a level which is equal to the pulse being measured. This allows simple measurement of peak pulse power with a basic accuracy of 1.5 dB even when the waveform is not rectangular. A custom calibration chart increases accuracy to 0.6 dB for critical applications.

Applications

Information on virtually all aspects of microwave power measurement, including detailed descriptions and illustrations of instruments, measurement techniques, error analysis, and applications, is contained in Application Note 64. Sources of measurement error and systematic methods for error reduction allow selection of the best procedure for specific applications. Application Note 64, entitled "Microwave Power Measurement", is available on request through your Hewlett-Packard Sales Office.

Steps toward better accuracy

The fundamental standards of microwave power lie in dc or low-frequency ac voltage and resistance standards which may be accurately measured and used for comparison or substitution. Other factors, such as impedance matching and efficiency of the sensing device, also play an important role in overall measurement accuracy.

The basic accuracy of Hewlett-Packard power measuring equipment satisfies the requirements of most applications without complicated setups requiring extensive manual operations and calculation. Should greater accuracy be required, the versatility and stability of Hewlett-Packard equipment allows easy enhancement of its basic accuracy in a step-by-step manner until the degree of accuracy needed is achieved.

Effective Efficiency and Calibration Factor

A power meter can only be responsive to the power which is actually dissipated within its sensor elements. Power which is dissipated elsewhere in the sensor or reflected by it will not be indicated. Furthermore, the spatial distribution of current and resistance within the sensor elements differs for power at microwave frequencies and the dc or audio power used for reference or substitution. The effects of these sources of error are measured at a number of frequencies for all Hewlett-Packard power sensors and temperature-compensated thermistor mounts and presented on the nameplate as Effective Efficiency and Calibration Factor.

For thermistor mounts, Effective Efficiency is the ratio of substituted bias power in the power meter to the microwave power absorbed by the mount. Effective Efficiency accounts for all losses except the reflection due to impedance mismatch. Calibration Factor is the ratio of substituted bias power in the meter to the microwave power incident on the mount. Calibration Factor, therefore, accounts for all losses. Although direct traceability to the National Bureau of Standards is not yet available in certain bands, the extensive tests and crosschecks conducted by Hewlett-Packard on literally thousands of mounts assure a high level of confidence in the calibration of all mounts. In addition, the mounts are swept-frequency tested to reveal any "holes" in their response.

For the thermocouple power sensor, the same concepts apply. However, to simplify operation, the data is presented as a Calibration Factor which normalizes the data to the value at 50 MHz. In this way, the Calibration Factor at 50 MHz (the frequency of the internal Power Reference) is always 100% and calibration is simplified for the user. Effective Efficiency data is not displayed since the extremely low SWR of the power sensor means it varies only slightly from the Calibration Factor.

Tuners

In most applications it is sufficient to correct for the various losses associated with the sensor by using Calibration Factor data. Source mismatch (SWR) is also a factor in any power measurement, and the combination of source and load SWR can result in serious mismatch errors. Uncertainty can be reduced by using an HP 870A Slidescrew Tuner, ahead of the sensor. When a tuner is used, only correction for Effective Efficiency is necessary. Of course, the lower the sensor SWR, the smaller the effect of mismatch will be; maximum accuracy is always obtained from the lowest SWR. In the case of the model 8481A Power Sensor, the reflection coefficient in both magnitude and *phase* is supplied for 17 frequencies from 2 - 18 GHz. By making the same measurement on the source under test, you can calculate the effect of mismatch and eliminate this source of error.

Instrumentation

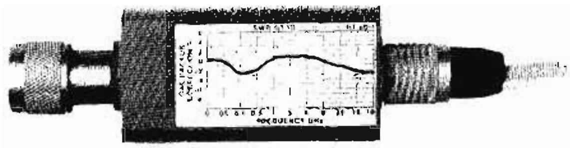
Maximum instrumentation uncertainty of the model 435A Power Meter is ±1% of full-scale on all ranges. This uncertainty can be reduced by directly measuring the voltage at the recorder output. A digital voltmeter, such as the Hewlett-Packard 3480A, may be used.

The 432-series of Power Meters provides instrumentation accuracy of ±1% (±0.5% with the digital readout of the 432B and 432C) in measuring the substituted power to the thermistor. Rear panel connectors allow direct measurement of the bridge voltages and computation of substituted dc power to within ±0.2% ±0.5 μW.

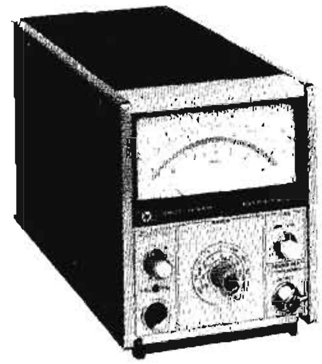
THERMOCOUPLE POWER METER

Accuracy plus convenience

Models 435A, 8481A



8481A



435A

Accurate power measurements

The 435A Power Meter and 8481A Power Sensor represent a significant advance in microwave power measurement. The power measurement circuit consists of a thermocouple sensing element which delivers a dc output voltage proportional to input power, a chopper stabilized amplifier, and a calibrated meter circuit.

Overall measurement accuracy is dependent on careful consideration of all sources of error. Instrumentation uncertainty, mismatch uncertainty, and sensor calibration must all be considered to arrive at a final accuracy figure.

Mismatch is usually the largest single source of error in power measurement. The VSWR of the sensor must be reduced to an extremely low level to obtain high measurement accuracy.

The accuracy of any power measurement in a thermocouple power meter depends on the accuracy of the thermocouple sensitivity. Therefore, some method must be provided to allow matching the sensor to a particular meter and accounting for physical changes in the sensing element.

8481A Power Sensor

Wide frequency and amplitude range

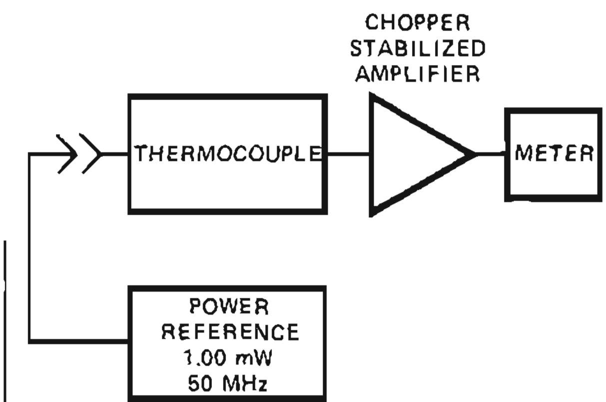
Measure power from 0.3 μW to 100 mW over a frequency range from 5 MHz to 18 GHz with a single Power Sensor.

Low VSWR reduces measurement uncertainty

A silicon monolithic thermocouple is used as the sensing element and its small physical size allows reduction of VSWR to <1.18 over the range to 10 GHz and <1.28 to 18 GHz. This assures low mismatch uncertainty, usually the largest single source of error in power measurement.

Individually calibrated

Each sensor is individually calibrated, traceable to the National Bureau of Standards, and a Cal Factor control on the meter compensates for Power Sensor efficiency at any frequency. In addition, computer calibration at 17 frequencies for Cal Factor and reflection coefficient in magnitude and phase is supplied. This means you can eliminate mismatch uncertainty by calculating the mismatch error.



- **0.3 μW to 100 mW**
- **5 MHz to 18 GHz**
- **VSWR <1.18 to 10 GHz**

435A Power Meter

Improved overall measurement accuracy

Low instrumentation uncertainty (<±1%) and a built-in power reference contribute to the overall measurement accuracy. The power reference assures that the meter is properly matched to the thermocouple sensitivity, a prerequisite to highest accuracy and confidence in the measurement.

Low drift-auto zero

Even on the lowest range, drift and noise are less than 1.5%. In those cases where occasional zeroing of the meter is required, this may be accomplished by merely depressing a front panel switch.

Battery operation—long cables

An FET chopper amplifier in the Power Sensor provides a relatively high output level with low power consumption. Thus, long cables (up to 200 feet) can be used in the Power Sensor circuit to allow remote power monitoring. Also, an optional internal battery allows truly portable operation.

Recorder output

Long-term power monitoring and leveling of sweep oscillators may be accomplished by utilizing the recorder output.

Specifications 435A and 8481A

Frequency range: 5 MHz to 18 MHz.

Power range: 55 dB with 10 full-scale ranges of 3, 10, 30, 100, and 300 μW; 1, 3, 10, 30, and 100 mW; also calibrated in dB from −25 dBm to +20 dBm full scale in 5 dB steps.

System accuracy:

Instrumentation Uncertainty: ±1% of full scale on all ranges (0° to 55°C).

Zero carryover: ±0.5% of full scale when zeroed on the most sensitive range.

Reference oscillator accuracy: ±0.70% (1 mW at 50 MHz, traceable to National Bureau of Standards).

Noise and drift: <1.5% of full-scale peak on 3 μW range, less on higher ranges (Typical, at constant temperature).

Response time: 2 seconds on 3 μW range, 0.6 second on 10 μW range, 0.25 second on 30 μW range, and 100 msec on all other ranges. (Typical, time constant measured at recorder output.)

435A Power Meter

Ref Osc: Internal oscillator with Type N female connector on front panel or rear panel (Option 003 only). Power output 1.00 mW ±0.70% at 50 MHz.

Stability: ±0.02%/°C (0°-55°C).

Zero: Automatic, operated by front panel switch.

Cal Factor: 16-position switch normalizes meter reading to account for Calibration Factor or Effective Efficiency. Range 85% to 100% in 1% steps. 100% position corresponds to Calibration Factor at 50 MHz.

Recorder output: Proportional to indicated power with 1 volt corresponding to full scale; 1 kΩ output impedance, BNC connector.

RF blanking output: Provides a contact closure to ground when auto-zero mode is engaged.

Cal Adj: Front panel adjustment provides capability to adjust gain of meter to match power sensor in use.

Power: 100, 120, 220, or 240 V +5%, −10%, 48 to 440 Hz, less than 10 watts.

Weight: Net, 5 lb, 12 oz (2,6 kg). Shipping, 9 lb, 3 oz (4,2 kg).

Dimensions: 6-3/32 in. high, 5⅛ in. wide, and 11 in. deep (155 x 130 x 279 mm).

Accessories furnished: 5 ft (1,52 m) cable for 8481A Power Sensor; 7½ ft (2,29 m) power cable. Mains plug shipped to match destination requirements.

Accessories available:

11683A Range Calibrator. (To be announced.)

11076A Carrying Case.

5060-8762 Rack Adapter Frame (holds three instruments the size of the 435A).

Combining cases:

1051A, 11¼ in. (286 mm) deep.

1052A, 16⅜ in. (416 mm) deep.

The combining cases accept the ⅓-module Hewlett-Packard instruments for bench use or rack mounting. See 1051A data sheet for details.

Options:

001: Rechargeable battery installed, provides up to 16 hours of continuous operation, add $100.

002: Input connector placed on rear panel in parallel with front, add $25.

003: Input connector and calibrator on rear panel only add $10.

009: 10-foot (3,05 m) cable for power sensor, add $30.

010: 20-foot (6,10 m) cable for power sensor, add $50.

011: 50-foot (15,24 m) cable for power sensor, add $100.

012: 100-ft (30,48 m) cable for power sensor, add $150.

013: 200-foot (60,96 m) cable for power sensor, add $250.

Price:

Model 435A, $550.

8481A Power Sensor

RF impedance: 50Ω nominal.

Reflection coefficient: <0.092 (SWR 1.18), 30 MHz to 10 GHz, <0.15 (SWR 1.28), 10 to 18 GHz, <0.25 (SWR 1.7), 10 MHz to 30 MHz.

Maximum Average Power: 300 mW.

Maximum Peak Power: 100 W.

Maximum Energy per Pulse: 10 W-μsec.

RF Connector: Type N male.

Power Sensor Calibration: Cal Factor data individually calibrated for each power sensor. Each sensor also supplied with individual computer calibration at 17 frequencies for Cal Factor and phase and magnitude of reflection.

Options:

001: Precision 7 mm (APC-7) connector, add $25.

003: 20 dB, 10 W Attenuator included. Extends measurement range to 10 W. (To be announced.)

Weight: Net, 6 oz (0,2 kg). Shipping, 1 lb (0,5 kg).

Dimensions: 1-3/16 in. wide, 1½ in. high, and 4⅛ in. long (30 x 38 x 105 mm) (includes RF connector).

Price: $350.

POWER METERS
Automatic zero, high accuracy
Models 432A, B, C

Automatic zeroing: Depress a front panel toggle switch and the 432 Power Meter automatically resets to zero in a fraction of a second.

DC bridge circuit: Using dc instead of the conventional 10 kHz bias current results in three benefits: 1) No signal emission from the mount to disturb sensitive circuits 2) meter zeroing is independent of the impedance connected to the RF input of the thermistor mount 3) the instrument is not affected by capacitance changes caused by movement of the thermistor mount cable.

High accuracy—no thermoelectric error: High accuracy over a wide temperature range is featured on the 432 Power Meters. By measuring the output voltage of the thermistor bridges, and computing the corresponding power, even higher accuracy of ±0.2% ±0.5 μW can be obtained.

Accuracy is maintained on even the most sensitive range because the error due to thermoelectric effect is reduced to a negligible level.

Recorder outputs—analog and digital: A rear panel connector provides an analog voltage proportional to the meter reading on all 432 Power Meters. In addition, the 432B and 432C Digital Power Meters feature BCD output of power reading—standard.

Long cable options: Thermistor mount cables up to 10 feet long can be used without special matching of the bridge circuit. Optional cables up to 200 feet long may be used if the cable is matched to the bridge circuit.

Calibrated mounts: Each thermistor mount is furnished with data stating the Calibration Factor* and Effective Efficiency* at various frequencies across the operating range. For easy and accurate power measurements, the front panel of the 432 contains a calibration factor control, calibrated in 1% steps from 88% to 100%, that compensates for losses in the mount and eliminates the need for calculation.

Convenient calibration: Verification of full-scale calibration on all ranges is provided by the 8477A Power Meter Calibrator described on page 374.

Specifications

Instrument type: automatic, self-balancing power meter for use with temperature-compensated thermistor mount.

Power range

- **432A:** seven ranges with full scale readings of 10, 30, 100, and 300 μW, 1, 3, and 10 mW; also calibrated in dBm from −20 dBm to +10 dBm full scale in 5 dB steps.
- **432B, 432C:** four ranges with full scale readings of 10 and 100 μW, and 1 and 10 mW.

Noise: less than 0.25% of full scale peak.

Response time: at recorder output, 35 ms times constant (typical).

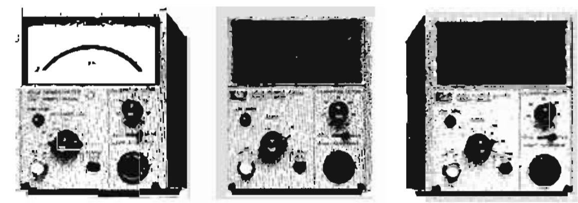
Fine zero: automatic, operated by front panel switch. Remote fine zero may be accomplished with 432C.

Zero carryover: less than 0.50% of full scale when zeroed on most sensitive range.

RFI: meets all conditions specified in MIL-I-6181D.

Meter

- **432A:** taut-band suspension, individually computed calibrated, mirror-backed scales. Milliwatt scale more than 4¼" (108 mm) long.



432A 432B 432C

- **432B, 432C:** three digits with one digit overrange. 20% overrange capability on all ranges.

Calibration factor control: 13-position switch normalizes meter reading to account for thermistor mount calibration factor. Range 100% to 88% in 1% steps.

Thermistor mount: external temperature-compensated thermistor mounts required for operation (HP 478, 8478B, and 486 Series; mount resistance 100 or 200 ohms).

Recorder output: proportional to indicated power with 1 volt corresponding to full-scale. 1 kΩ output impedance.

BCD output: 8, 4, 2, 1 code: "1" positive. TTL compatible logic. Operates with HP 5055A Digital Recorder. "Print" and "Inhibit" lines available. (432B and 432C only.)

Bridge outputs (V_{RF} and V_{COMP}): direct connections to the thermistor bridges; used in instrument calibration and precision power measurements.

Model 432C control lines: (note: instrument is referenced to +5 V, "Logic 0" is equivalent to 0 V).

Outputs

- **BCD** output as described above.
- **Overrange:** single bit indicates meter overrange.
- **Underrange:** single bit indicates meter underrange.
- **Range:** two-bit code indicates range selected.
- **Print:** single bit indicates data is ready.

Inputs

- **Remote enable:** single bit establishes control of instrument ranging and fine zero controls for remote programming. Remote fine zero may be accomplished in remote or local modes of operation.
- **Remote range:** two-bit code selects instrument range.

Auto zero: contact closure to ground or TTL "0" zeros meter.

- **Inhibit:** single bit holds data and stops A/D converter.
- **External trigger:** when in inhibit mode, single bit starts new data conversion. Data ready in 10 msec.
- **Inputs and outputs:** compatible with 5055A Digital Recorder and 12566A interface card for 2100 Series computers.

Power

- **432A:** 115 or 230 V ac ±10%, 50 to 400 Hz, 2½ watts. Optional rechargeable battery provides up to 24 hours continuous operation. Automatic battery recharge.
- **432B:** 115 or 230 V ac ±10%, 50 to 400 Hz, 10 watts.
- **432C:** 115 or 230 V ac ±10%, 50 to 400 Hz, 16 watts.

Weight

- **432A:** net, 6 lbs 14 oz (3,1 kg); shipping, 10 lbs 5 oz (4,7 kg).
- **432B:** net, 6 lbs 14 oz (3,1 kg); shipping, 10 lbs 5 oz (4,7 kg).
- **432C:** net, 17 lbs (3,2 kg); shipping, 10 lbs 7 oz (4,8 kg).

(continued on next page)

* "Calibration Factor" and "Effective Efficiency" are figures of merit expressing the ratio of the substituted signal measured by the power meter to the microwave power incident on and absorbed by the mount, respectively.

THERMISTOR MOUNTS, CALIBRATOR
Broad Frequency coverage
Models 478A, 8478B, 486 Series, 8477A

(continued from previous page)

Dimensions: 5⅛" wide, 6-3/32" high, 11" deep (130 x 155 x 279 mm).

Accessories furnished: 5 ft (1,52 m) cable for Hewlett-Packard temperature-compensated thermistor mounts; 7½ ft (2,29 m) power cable. Main plugs shipped to match destination requirements.

Options

001: rechargeable battery installed, provides up to 24 hours continuous operation (432A only), add $100.

002: input connector placed on rear panel in parallel with front, add $25.

003: input connector on rear panel only, add $10.

(Note: thermistor mount cable impedance is part of the 432 input bridge circuit. For cables over 10 feet long, the bridge is matched to specific cable options, so the various cables should not be interchanged.)

009: 10 ft (3,05 m) cable for 110-ohm or 200-ohm mount, add $30.

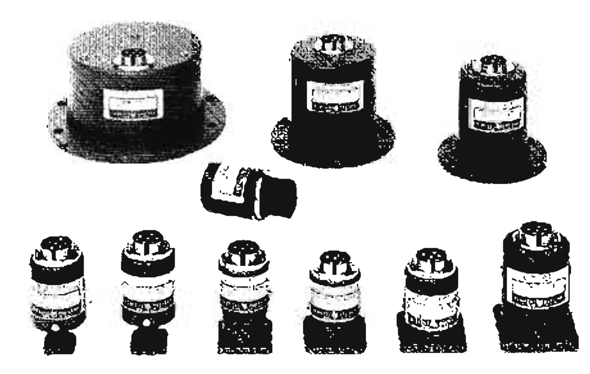
010: 20 ft (6,10 m) cable for 100-ohm or 200-ohm mount, add $50.

011: 50 ft (15,24 m) cable for 100-ohm or 200-ohm mount, add $100.

012: 100 ft (30,48 m) cable for 100-ohm or 200-ohm mount, add $150.

013: 200 ft (60,96 m) cable for 100-ohm or 200-ohm mount, add $250.

Price: Model 432A, $575; Model 432B, $975; Model 432C, $1375.



478A, 486 Series

Temperature-compensated Thermistor Mounts

High efficiency and good RF match are characteristic of the HP 478A and 8478B Coaxial and 486A-Series Waveguide Thermistor mounts which, in conjunction with the 432 Power Meter, provide you with high accuracy even in routine power measurements. These thermistor mounts are temperature-compensated for low drift, even in the presence of thermal shocks, permitting measurement of microwave power as low as one microwatt. Each mount contains data showing Calibration Factor and Effective Efficiency at six frequencies, directly traceable to the National Bureau of Standards at those frequencies where NBS provides calibration service.

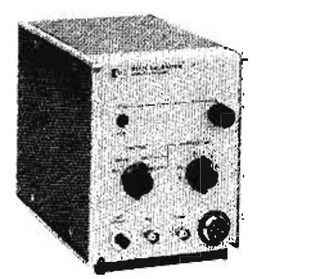
Specifications

HP Model[1]	Frequency range, GHz	Maximum SWR	Operating resistance (ohms)	Price
478A	10 MHz to 10 GHz	1.75, 10 to 25 MHz 1.3, 25 MHz to 7 GHZ 1.5, 7 to 10 GHz	200	$195
8478B[2]	10 MHz to 18 GHz	1.75, 10 to 30 MHz 1.35, 30 to 100 MHz 1.1, 0.1 to 1 GHz 1.35, 1 to 12.4 GHz 1.6, 12.4 to 18 GHz	200	$325[4]
S486A	2.60 to 3.95	1.35	100	$390
G486A	3.95 to 5.85	1.5	100	$275
J486A	5.30 to 8.20	1.5	100	$275
H486A	7.05 to 10.0	1.5	100	$275
X486A	8.20 to 12.4	1.5	100	$190
M486A	10.0 to 15.0	1.5	100	$335
P486A	12.4 to 18.0	1.5	100	$240
K486A[3]	18.0 to 26.5	2.0	200	$350
R486A[3]	26.5 to 40.0	2.0	200	$395

[1] 11528A Adapter adapts mount to 430 Series Power Meter (thermistor circuit unbalanced, no temperature compensation), $10.
[2] 11527A Adapter adapts 8478B to 431A/B Power Meters (thermistor circuit unbalanced), $25.
[3] Circular flange adapters: K-band (UG-425/U) HP 11515A, $60 each; R-band UG-381/U) HP 11516A, $50 each.
[4] Option 011, furnished with APC-7 RF connector, add $25.

8477A Power Meter Calibrator

The 8477A Calibrator is specifically designed for use with the 432 Power Meter. It allows you to verify full-scale meter readings on all ranges, and meter tracking. Simply connect three cables between the power meter and calibrator; no charts or additional instruments are required.



8477A

Specifications, 8477A

Calibration points: outputs corresponding to meter readings of: 0.01, 0.03, 0.1, 0.3, 1.0, 2.0, 3.0, and 10 mW (for mount resistance switch settings of both 100 and 200 ohms).

Calibration uncertainty: ±0.2% on the top five ranges, and ±0.5% on the 0.01 and 0.03 mW ranges from +20° to +30°C.

RFI: meets all conditions specified in MIL-I-6181D.

Power: 115 or 230 V ±10%, 50-400 Hz, approximately 2 W.

Weight: net, 4½ lbs (2,0 kg); shipping, 6¼ lbs (2,9 kg).

Dimensions: 6-3/32" high, 5⅛" wide, 8" deep (155 x 130 x 203 mm).

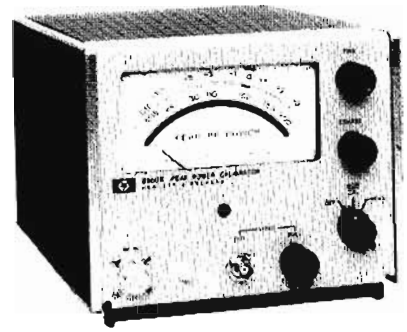
Price: Model 8477A, $495.

PEAK POWER CALIBRATOR
Measure independent of pulse width
Model 8900B

Features:

- Measures true peak power ±0.6 dB absolute
- Measurement completely independent of repetition rate and pulse width (>0.25 μsec)
- Readily standardized against external bolometer or calorimeter
- Incorporates wide-band (7 MHz) detector output for pulse monitoring

The HP 8900B peak power calibrator provides a convenient means for measuring the peak RF power of pulses in the range from 50 to 2000 MHz. The power level is read out directly on the panel meter and is completely independent of repetition rate and pulse width (>0.25 μsec).



8900B

Specifications

Radio frequency measurement characteristics

RF range: 50 to 2000 MHz.

RF power range: 200 mW peak full scale (may be readily increased through use of external attenuators or directional couplers).

RF power accuracy: ±1.5 dB (±0.6 dB with custom calibration curve furnished with instrument).

RF power precision: 0.1 dB.

RF pulse width: >0.25 μs.

RF repetition rate: 1.5 MHz maximum.

RF impedance: 50 ohms.

RF VSWR: <1.25.

Monitor output

Level: >0.2 volt for 20 mW input (nominal).

Impedance: 150 ohms nominal.

Bandwidth: >7 MHz.

Physical characteristics

Dimensions: 7¾" wide, 6⅛" high, 11" deep (197 x 156 x 279 mm).

Weight: net, 10 lbs (4,5 kg); shipping, 13 lbs (5,9 kg).

Power: 105 to 125 or 210 to 250 volts, 50 to 60 Hz.

Thermistor Mounts Models 477B, X487B, P487B

The Model 477B Thermistor Mount allows measurements from 10 MHz to 10 GHz, and the 487-series waveguide mounts cover the 8.2-18.0 GHz frequency range. These uncompensated thermistor mounts may be used with a variety of power meters such as the HP 430-series. Approximately 13 mA bias current is required to obtain the nominal resistance of the thermistor.

Specifications, 477B thermistor mount

Frequency range: 10 MHz to 10 GHz.

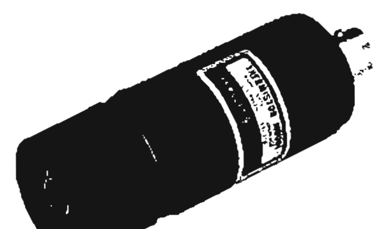
Reflection coefficient: full range, <0.2 (1.5 SWR, 14 dB return loss); 50 MHz to 7 GHz, <0.13 (1.3 SWR, 17.7 dB return loss).

Power range: 0.01 to 10 mW (with HP 430C) 10 mW maximum average power; 1 W maximum peak power.

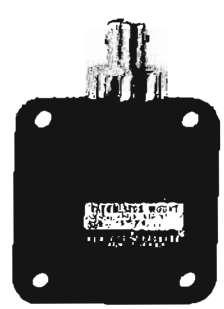
Element: 200-ohm, negative temperature coefficient themistor included; approximately 13 mA bias required.

RF connector: Type N male.

Price: HP 477B, $135.



477B



X487B

Specifications, 487 Thermistor Mounts

HP Model	Maximum SWR	Frequency range* GHz	Price
X487B	1.5	8.2 - 12.4	$150
P487B	1.5	12.4 - 18.0	$175

*HP 486A Waveguide Thermistor Mounts are available in S- through R-band (2.6 to 40 GHz); 11528A Adapter required.

POWER & NOISE FIGURE METERS

NOISE FIGURE METERS; SOURCES

Automatic noise figure measurements to 18 GHz

Models 340B, 342A; 343A, 345B, 347A, 349A

In microwave communications, radar, etc., the weakest signal that can be detected is usually determined by the amount of noise added by the receiving system. Thus, any decrease in the amount of noise generated in the receiving system will produce an increase in the output signal-to-noise ratio equivalent to a corresponding increase in received signal. From a performance standpoint, an increase in the signal-to-noise ratio by reducing the amount of noise in the receiver is more economical than increasing the power of the transmitter.

The quality of a receiver or amplifier is expressed in a figure of merit, or noise figure. Noise figure is the ratio, expressed in dB, of the actual output noise power of the device to the noise power which would be available if the device were perfect and merely amplified the thermal noise of the input termination rather than contributing any noise of its own.

The Hewlett-Packard system of automatic noise figure measurement depends upon the periodic insertion of a known excess noise power at the input of the device under test. Subsequent detection of noise power results in a pulse train of two power levels. The power ratio of these two levels contains the desired noise figure information. Hewlett-Packard noise figure meters automatically measure and present this ratio directly in dB of noise figure.

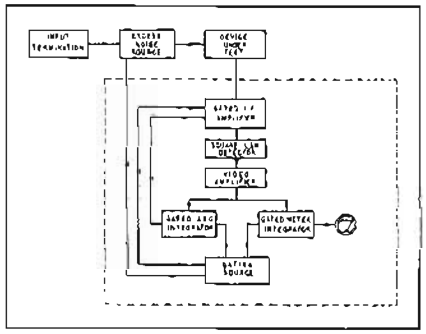


Figure 1. Automatic noise figure measurement system.

Noise figure is discussed in detail in Hewlett-Packard Application Note 57, which is available from your local Hewlett-Packard field office upon request. Application Note 57, "Noise Figure Primer," derives noise figure formulas, describes general noise figure measurements and discusses accuracy considerations. One of the measurement systems discussed in Application Note 57 is shown in Figure 1. The portion of the diagram within the dashed box is a simplified block diagram of the HP 340B and 342A Noise Figure Meters, and the excess noise source could be any of the noise sources described on these pages.

Advantages:

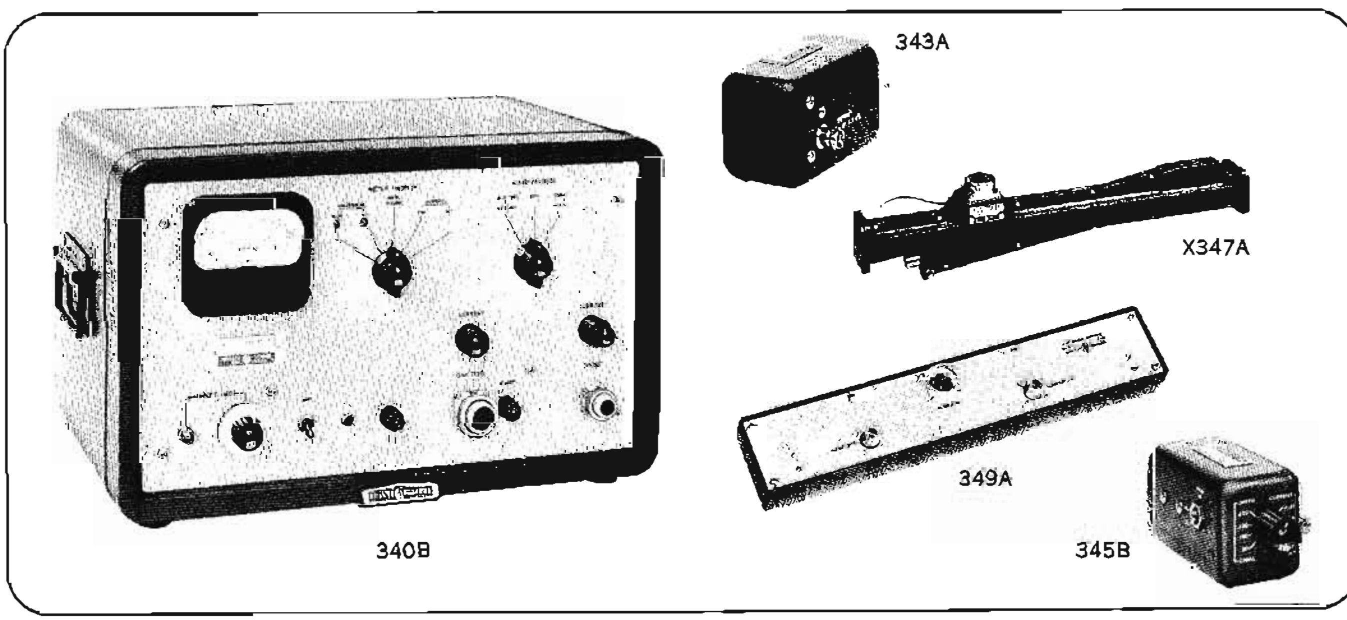
- Reads noise figure directly in dB
- Completely automatic measurement
- Easily used by nontechnical personnel
- No periodic recalibration needed
- Fast response; ideal for recorder operation

Uses:

- Measure noise figure in microwave or radar receivers, RF and IF amplifiers
- Compare unknown noise sources against known noise levels
- Adjust parametric amplifiers for optimum noise figure

HP noise figure meters and noise sources offer time-saving and cost-reducing advantages. Their ease of operation and continuous, automatic metering of noise figure reduce the time required for alignment and adjustment and simplify measurements so that they can be done by nontechnical personnel. No periodic recalibration of the meters is needed, and accurate alignment is easy, so high-level, on-line performance is assured.

In operation, a noise source is connected to the input of the device under test. The IF output of the device is connected to the 340B or 342A. The noise figure meter gates the noise source on and off. When the noise source is on, the noise level is that of the device plus the noise source. When the noise source is off, the noise level is that of the



device and its termination. The noise figure meter automatically compares the two conditions and displays noise figure directly in dB. Power to operate the noise source is supplied by the noise figure meter. Simply connect the noise source, adjust drive current using the controls and meter on the 340B or 342A, and the noise source is ready for operation.

Noise figure meters

Model 340B Noise Figure Meter, when used with an HP noise source, automatically measures and continuously displays noise figure for frequencies of 30 and 60 MHz. On special order up to four custom frequencies between 10 and 70 MHz, and some frequencies outside this range, can be supplied.

Model 342A is similar to Model 340B, except that it operates on five frequencies: 60, 70, 105, 200, and the basic tuned-amplifier frequency of 30 MHz. Up to six custom frequencies between 10 and 200 MHz, including 21.4 MHz, are available on special order.

Noise sources

Hewlett-Packard 343A VHF Noise Source: Specifically for IF and RF amplifier noise measurement, a temperature-limited diode source with broadband noise output from 10 to 600 MHz with 50-ohm source impedance and low SWR.

Hewlett-Packard 345B IF Noise Source: Operates at either 30 or 60 MHz, as selected by a switch; another selector permits matching 50-, 100-, 200-, and 400-ohm impedances.

Hewlett-Packard 347A Waveguide Noise Source: Argon gas discharge tubes mounted in waveguide sections; for waveguide bands 3.95 through 18 GHz, they provide uniform noise throughout the range; maximum SWR is 1.2.

Hewlett-Packard 349A UHF Noise Source: Argon gas discharge tubes in Type N coaxial configuration for automatic noise figure readings, 400 to 4000 MHz.

Specifications, 340B and 342A

Noise figure range: 5.2 dB noise source, 0 to 15 dB, indication to infinity; 15.2 dB noise source, 3 to 30 dB, indication to infinity.

Accuracy (excluding source accuracy): noise diode scale: ±0.5 dB, 0 to 15 dB; gas tube scale: ±0.5 dB, 10 to 25 dB; ±1 dB, 3 to 10 dB and 25 to 30 dB.

Input frequency: 340B: 30 or 60 MHz, selected by switch; 342A: 30, 60, 70, 105, and 200 MHz, selected by switch. Other frequencies available; prices and details on request.

Bandwidth: 1 MHz minimum.

Input requirements: −60 to −10 dBm (noise source on); corresponds to gain between noise source and input of approximately 50 to 100 dB for 5.2 dB noise source and 40 to 90 dB for 15.2 dB noise source.

Input impedance: 50 ohms nominal.

AGC output: nominal 0 to −6 V from rear binding posts.

Recorder output: 1 mA maximum into 2000 ohms maximum.

Power input: 115 or 230 volts ±10%, 50 to 60 Hz, 185 to 435 watts, depending on noise source and line voltage.

Power output: sufficient to operate 343A, 345B, 347A or 349A Noise Sources.

Dimensions: cabinet: 20¾" wide, 12¾" high, 14½" deep (527 x 324 x 368 mm); rack mount: 19" wide, 10-15/32" high, 13⅞" deep behind panel (483 x 266 x 353 mm).

Weights: net 43 lb (19.4 kg), shipping 53 lb (23.9 kg) (cabinet); net 36 lb (16.2 kg), shipping 50 lb (22.5 kg) (rack mount).

Accessory furnished: one 340A-16A Cable Assembly, connects noise figure meter to 347A or 349A Noise Source.

Price: HP 340B, $1075 (cabinet); HP 340BR, $1060 (rack mount); HP 342A, $1185 (cabinet); HP 342AR, $1170 (rack mount); not available in all countries.

Specifications, 343A

Frequency range: 10 to 600 MHz.

Excess noise ratio[1]**:** 10 to 30 MHz, 5.20 dB ±0.20 dB; 100 MHz, 5.50 dB ±0.25 dB; 200 MHz, 5.80 dB ±0.30 dB; 300 MHz, 6.05 dB ±0.30 dB; 400 MHz, 6.30 dB ±0.50 dB; 500 MHz, 6.50 db ±0.50 dB; 600 MHz, 6.60 dB ±0.50 dB.

Source impedance: 50 ohms.

Reflection coefficient: <0.091 (1.2 SWR), 10 to 400 MHz; <0.13 (1.3 SWR), 400 to 600 MHz.

Noise generator: temperature-limited diode.

Dimensions: 2¾" wide, 2½" high, 5" deep (70 x 63 x 127 mm).

Weight: net ¾ lb (0,34 kg); shipping 2 lbs (0,9 kg).

Price: HP 343A, $160.

Option 001: spare noise diode(s) calibrated and supplied with instrument, add $40 each.

Specifications, 345B

(same weight and dimensions as 343A)

Spectrum center: 30 or 60 MHz, selected by switch.

Excess noise ratio[1]**:** 5.2 dB.

Source impedance: 50, 100, 200 or 400 ohms, ±4%, as selected by switch; less than 1 pF shunt capacitance.

Noise generator: temperature-limited diode.

Price: HP 345B, $215 (operation at any two frequencies between 10 and 60 MHz in lieu of 30 and 60 MHz available on special order).

Specifications, 347A

HP Model	Range (GHz)	Excess noise ratio[1,2]	Approx. length (in.)	Approx. length (mm)	Price
G347A	3.95— 5.85	15.2 ±0.5	19	483	$485
J347A	5.30— 8.20	15.2 ±0.5	19	483	$485
H347A	7.05—10.0	15.6 ±0.5	16	406	$490
X347A	8.20—12.4	15.7 ±0.4	14¾	375	$405
P347A	12.4 —18.0	15.8±0.5	14¾	375	$430

Reflection coefficient for all models, fired or unfired, 0.091 (SWR 1.2) max. (source terminated in well-matched load).

Specifications, 349A

Frequency range: 400 to 4000 MHz, wider with correction.

Excess noise ratio[1]**:** 15.6 dB ±0.6 dB,[2] 400 to 1000 MHz; 15.7 dB ±0.5 dB,[2] 1000 to 4000 MHz.

SWR: <1.35 (fired), <1.55 (unfired) up to 2600 MHz; <1.55 (fired or unfired), 2600 to 3000 MHz; <2.0 (fired), <3.0 (unfired) 3000 to 4000 MHz.

Dimensions: 3" wide, 2" high, 15" long (76 x 51 x 381 mm).

Weight: net 3¼ lb (1,4 kg); shipping 6 lb (2,7 kg).

Price: HP 349A, $350.

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[1] $ENR\,(dB) = 10 \log \frac{k(T - T_0)B}{kT_0B}$

where kTB = available noise power,

and kT_0B = available noise power with noise source at 290° K.

[2] Includes factor for insertion loss.

BASIC INSTRUMENTS FOR MICROWAVE MEASUREMENTS
Frequency, impedance, attenuation

Microwave measuring techniques

Hewlett-Packard offers a complete line of microwave test equipment from which systems can be assembled for making accurate reflections, transmission and frequency measurements. Equipment ranges from inexpensive CW systems which measure a magnitude response to powerful network analyzers which furnish a dynamic CRT display of frequency swept magnitude and phase. Measurement techniques and equipment functions are discussed briefly in the following paragraphs. More detailed information is available in Application Notes 64, 65, and 84, complimentary copies are available from Hewlett-Packard sales offices.

Frequency measurements

There are two general classes of frequency measuring devices—active and passive types. Electronic counters, transfer oscillators, and frequency converters are examples of active types. HP manufactures a complete line of these instruments which measure frequency with accuracies of a few parts in 10^5.

Where the accuracy of active devices is not required, passive devices offer direct readout at a considerable saving in cost. Passive transmission-type frequency meters, such as the HP 532, 536A, and 537A, are two-port devices that absorb part of the input power in a tunable cavity. When the cavity is tuned to resonance, a dip occurs in the transmitted power level. This dip can be observed on a meter or oscilloscope display of the detected RF voltage. Frequency is then read from a calibrated dial driven by the cavity tuning mechanism. The accuracy of cavity frequency meters depends upon the cavity Q, dial calibration, backlash, and effects of temperature and humidity variations. The frequency meters achieve accuracies of a few parts in 10^4.

Impedance measurements

Impedance-matching a load to its source is one of the most important considerations in microwave transmission systems. If the load and source are mismatched, part of the power is reflected back along the transmission line toward the source. This reflection not only limits maximum power transfer, but also can be responsible for erroneous measurements of other parameters or even cause circuit damage in high-power applications.

The signal reflected from the load interfers with the incident (forward) signal, causing standing waves of voltage and current along the line. SWR, which is the ratio of standing wave maxima to minima, is directly related to the impedance mismatch of the load. The standing wave ratio (SWR), therefore, provides a valuable means of determining impedance magnitude and mismatch. There are two common methods for measuring SWR; slotted line techniques and reflectometer techniques. A slotted line measures the ratio of standing wave maxima to minima while a reflectometer separates the incident and reflected voltage waves and then measures their ratio.

Slotted line techniques—single frequency

Standing-wave ratio can be measured directly with a slotted line in a setup like the one shown in Figure 1. The slotted line probe is loosely coupled to the RF field in the line, thus sensing relative amplitudes of the standing-wave pattern as the probe is moved along the line. The ratio of maxima to minima (SWR) is displayed directly on the SWR meter.

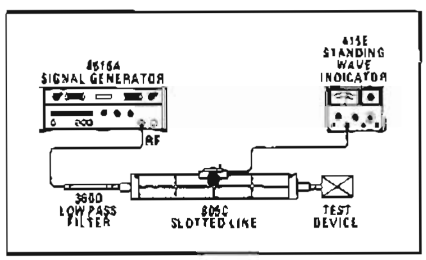


Figure 1. Typical setup for SWR measurements in coax.

Slotted lines feature low residual SWR and have the capability of inexpensive phase measurements compared to reflectometer techniques. While these methods work well for single-frequency testing, they are time-consuming for broadband applications.

The swept slotted line

A measuring system which combines the speed and convenience of swept-frequency measurements and the inherent accuracy of the slotted line can be built around the HP 817A Slotted Line System. The setup is identical to Figure 1 except that the source is replaced with a sweep oscillator, the slotted line is an 817A Option H03, and the 415E is replaced by the HP 8755A/181A. This system will operate throughout the frequency range from 1.8 to 18 GHz. The measurement results are displayed on a storage oscilloscope as an envelope of the SWR in dB. See Figure 2. At any given frequency, the ratio of the maximum and minimum amplitude of the

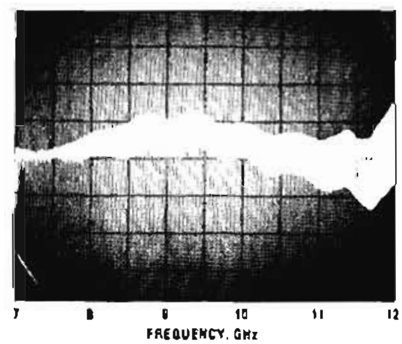


Figure 2. Multi-sweep slotted-line measurement. Vertical scale 0.5 dB/cm.

envelope is the SWR. A plot of SWR can be generated in a few seconds and retained on the CRT for evaluation or photography. Accuracy of slotted-line measurements is limited primarily by the residual SWR of the line itself, 1.01 in waveguide and 1.02 to 1.06 in coax depending upon the frequency and type of connector.

Reflectometer techniques

The reflection coefficient (ρ) of a device or system is another useful term in establishing the impedance match of microwave devices. The following relationships of ρ and SWR are frequently used in impedance work:

$$\rho = \frac{|E\ \text{reflected}|}{|E\ \text{incident}|} = \frac{\text{SWR}-1}{\text{SWR}+1}$$

Reflection coefficient (ρ) is a linear quantity varying between zero and one. The logarthmic expression of ρ is known as return loss and defined as: dB $= -20$ $\text{LOG}_{10}|\rho|$. A reflection coefficient of 1.0 (total reflection) therefore, corresponds to a return loss of 0 dB and a zero reflection coefficient corresponds to infinite dB return loss.

Reflection coefficient is measured by separating the incident and reflected waves propagated in the transmission line connecting the source and load. The reflectometer uses either coaxial or waveguide couplers to accomplish this separation. Reflectometers permit dynamic oscilloscope displays or permanent X-Y recordings of reflection coefficient or return loss across complete operating bands.

The waveguide reflectometer setup shown in Figure 3 is designed to hold the incident power constant by leveling. With automatic leveling, only the relative amplitude of the reflected wave need be measured to determine reflection coefficient.

To calibrate the reflectometer, a short circuit is placed at the output port, thus reflecting all of the incident power (zero dB return loss). The detector in the reverse-arm coupler samples the reflected power and provides a proportional dc voltage for readout. By placing a calibrated attenuator ahead of the detector specific amounts of return loss may be pre-inserted for calibrating the recorder gain. The attenuator is then returned to zero, the short removed, and the test device connected and measured on the pre-calibrated display. Measurements are also possible without the pre-insertion attenuator if the detector remains within its square law region.

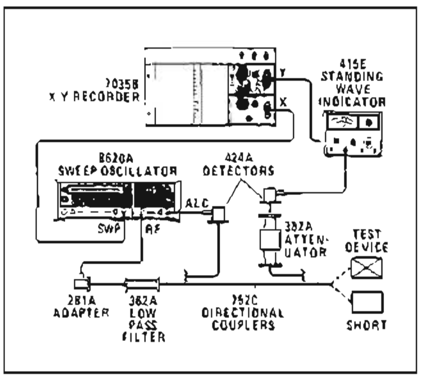


Figure 3. Typical waveguide reflectometer.

The reflectometer technique described is an economical way for making swept measurements (see Hewlett-Packard Application Note 65 for more information). However, greater speed and convenience is possible with the HP 8755 Series Frequency Response Test Sets. Measured data can be either plotted on an X-Y recorder or read directly from a fully calibrated CRT display. See Figure 5 and Hewlett-Packard Application Note 155.

Accuracy of reflectometer measurements is limited by directional coupler directivity. A residual SWR of 1.02 (40 dB directivity) is common in waveguide and 1.02 to 1.1 in coax depending on the frequency range and connectors.

Attenuation Measurements

Attenuation is defined as the decrease in power (at the load) caused by inserting a device between a Z_0 source and load. Under this condition, the measured value is a property of the device alone. The term Z_0 is used to describe a unity SWR condition where the load and source impedances equal the transmission line impedance.

There are three common methods for measuring RF attenuation: 1) square-law detection with audio substitution, 2) direct RF substitution, and 3) linear detection with IF substitution.

Square-law detection technique

Figure 4 shows a waveguide system for swept attenuation measurements of 25 to 30 dB. Source power is leveled using a 752-series 10 dB directional coupler in the ALC loop. Using two 752 directional couplers improves the Z_0 source and load matching requirements and improves the systems frequency response as well.

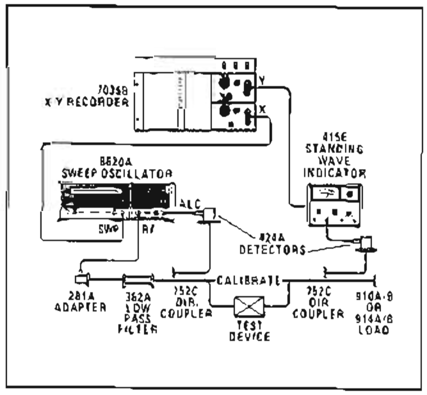


Figure 4. Swept attenuation system for measurements up to 30 dB.

With the 8620A sweeping the frequency range of interest, a zero-dB reference level is established on the x-y recorder without the test device in the system. The device is then inserted as indicated in Figure 4 and its attenuation versus frequency determined by the amplitude decrease from the reference level previously established.

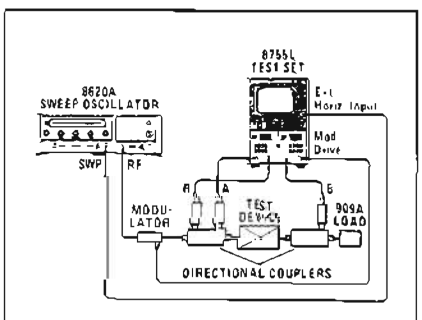


Figure 5. Setup for simultaneous swept measurement of insertion gain and return loss.

A much improved square-law detection technique uses the HP 8755L Frequency Response Test Set. The setup diagram in Figure 5 permits simultaneous measurements of attenuation and return loss over a continuous 60 dB dynamic range. Readout is either on a CRT display calibrated directly in dB or a X-Y recorder. The 8755A has a frequency range of 100 MHz to 18 GHz.

RF substitution technique

Swept attenuation measurements up to 45 to 50 dB can be made using the RF pre-insertion, X-Y recorder system shown in Figure 6. Coupler tracking and detector errors are eliminated by plotting a calibration grid on the X-Y recorder prior to the actual measurement. The grid is plotted by setting in specific values of attenuation on the 382A near the anticipated test device attenuation. The 382A is then set to 0 dB and the test device inserted as shown in Figure 6. A final sweep plots attenuation of the test device over the calibration grid.

IF substitution technique

The IF substitution technique of attenuation measurement involves conversion of the microwave frequency to a constant, much lower frequency for which very accurately calibrated attenuators are available. Detection at a constant IF frequency improves the system sensitivity permitting measurements over a wide (>60 dB) dynamic range.

The 8410A Network Analyzer is an instrument example where IF substitution is used thus allowing accurate measurements to be made over a frequency range of 110 MHz to 40 GHz. Compared to the other techniques mentioned in this section the network analyzers offer the latest in speed, measurement precision, and user convenience.

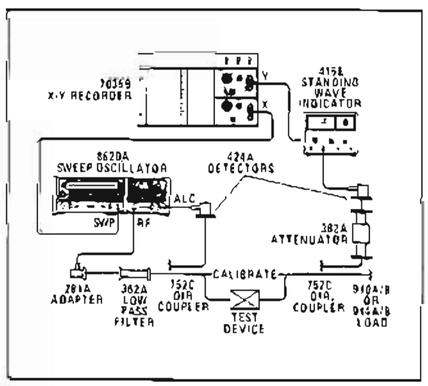


Figure 6. RF pre-insertion technique for swept attenuation measurements.

Hewlett-Packard now offers a 64 page comprehensive catalog of *coaxial and waveguide measurement accessories*. It contains complete information about our extensive selection of precision RF passive instruments and accessories.

Sections include: Directional Couplers, Slotted Line Equipment, Attenuators, Frequency Meters, Detectors, Mixers, Filters, Modulators, Terminations.

A free copy may be obtained through your local Hewlett-Packard field office.

COAXIAL INSTRUMENTATION

For coaxial systems operating to 18 GHz

Instrument name	Uses	Frequency coverage by model (dc, 10 MHz, 100 MHz, 215 MHz, 450 MHz, 500 MHz, 940 MHz, 1 GHz, 2 GHz, 3 GHz, 4 GHz, 10 GHz, 12.4 GHz, 18 GHz)
Adapters	Interconnect coaxial-waveguide and coaxial-coaxial systems	281A, 281B, 11524A, 11525A, 11533A, 11534A, 86428A
Low-pass filters	Output filters for signal sources to eliminate harmonics	360A, 360B, 360C, 360D, 11673A
Bandpass filters	Spectrum analyzer preselectors to eliminate signals outside the range of interest	8430A, 8431A, 8432A, 8433A, 8434A, 8435A, 8436A
Variable attenuators	Measurement of reflection coefficient, insertion loss, transfer characteristics by RF substitution; reduction of power levels; reduction of source mismatch	354A, 355C, E, 355D, F, 33300 Series, 393A, 394A
Fixed attenuators		8491A, 8491B, 8492A, 8493A, 8493B
Crystal Detectors	RF detection; reflection coefficient, attenuation measurements	420A, 420B, 423A, 440A, 8470A, 8471A, 8472A
Thermistor mount	Power measurements with HP 430C (477B), 432 series (478A, 8478B).	477B, 478A, 8478B
Frequency meters	Frequency measurements	536A, 537A
Dual directional couplers	Reflectometer measurements; power monitoring	774D, 775D, 776D, 777D, 778D
Directional detectors	Closed-loop leveling of signal sources; signal monitoring	786D, 787D, 788C, 789C

Instrument name	Uses	Frequency coverage by model (dc, 10 MHz, 100 MHz, 215 MHz, 450 MHz, 500 MHz, 940 MHz, 1 GHz, 2 GHz, 3 GHz, 4 GHz, 10 GHz, 12.4 GHz, 18 GHz)
Directional couplers	Power measurements; power leveling; reflection measurements; isolation	779D 796D 797D 798C
Slotted line System Slotted section Swept slotted line system	Measurement of SWR, wavelength, impedance; fixed and swept-frequency slotted line measurements	805C 816A 817A
Fixed and sliding loads	Fixed loads for terminating 50-ohm systems (908A, 909A) Sliding loads for separating load reflections from other system reflections (905A, 907A, 911A)	905A 907A 908A 909A 911A
PIN modulators	Sinusoidal and complex AM and RF pulsing of microwave sources without incidental FM	8731B, Opt. H10 8731A,B 8732A,B 8733A,B 8734A,B 33000C, D 33008C, D 33001C, D
Mixers	Mixing SHF and VHF signals	934A 10514A, B, C 10534A, B, C
Transistor fixtures	Make RF, dc connections to solid state devices	11600A 11602A 11608A
Bias networks	Apply dc bias to solid state devices in RF measuring systems	11589A 11590A 85426A
Coaxial switches	Electrically switch RF signals	8761
Air lines	Adapt test equipment port spacing to devices under test	11606A 11588A
Shorts	Establish measurement planes, reflection phase and magnitude references	11511A 11512A 11665A

WAVEGUIDE INSTRUMENTATION

For waveguide systems operating 2.60-40 GHz

Instrument Name	Uses	Family[1] Model Number	S 2.6-3.95	G 3.95-5.85	J 5.30-8.20	H 7.05-10.0	X 8.20-12.4	M 10.0-15.0	P 12.4-18.0	K 18.0-26.5	R 26.5-40.0
			Frequency coverage by band - GHz								
Adapters	Interconnect coaxial-waveguide systems	281A	X	X	X	X	X				
		281B					X		X		
	Interconnect two different waveguide systems	292A							X	X	
		292B					X	X			
Low-pass filters	Output filters for signal sources to eliminate harmonics	362A					X	X	X	X	X
Variable attenuators	Measurement of reflection coefficient, insertion loss, transfer characteristics by RF substitution; reduction of power levels; reduction of source mismatch	382A	X	X	X	X	X		X	X	X
		375A					X		X		
Crystal Detectors	RF detection; reflection coefficient, attenuation measurements	424A	X	X	X	X	X	X	X		
		422A								X	X
Detector mount	Tunable detector mount for accurate matching of waveguide sections to crystal or bolometer	485B					X				
Thermistor mount	Power measurements with 432 series (486A), and 430C (487B).	486A	X	X	X	X	X	X	X	X	X
		487B					X		X		
Frequency meters	Frequency measurements	532A			X	X			X	X	X
		532B					X				
Directional couplers	Power measurements; power leveling; reflection measurements; isolation	752A			X	X	X		X	X	X
		752C			X	X	X		X	X	X
		752D			X	X	X		X	X	X
Slotted line systems	Measurement of SWR, wavelength, impedance; fixed and swept-frequency slotted line measurements	810B		X	X	X	X		X		
		815B								X	X
PIN modulators	Sinusoidal and complex AM and RF pulsing of microwave sources without incidental FM	8735A					X				
		8735B					X				
Fixed and sliding loads	Fixed loads for terminating waveguide systems. Sliding loads for separating load reflections from other system reflections	910A			X	X			X		
		910B					X				
		914A		X	X	X			X		
		914B					X			X	X
Fixed and sliding shorts	Establish measurement planes, reflection phase and magnitude references	920A			X	X					
		920B							X	X	X
		923A					X				
		930A					X				
Mixers	Harmonic Mixer	932A							X		
Slide screw tuners	Correct discontinuities in waveguide	870A					X		X		
Phase shifters	Provide phase control	885A			X		X		X		

[1] Instrument model number consists of family model number prefixed by letter of waveguide band, E.G., X281B specifies X-band waveguide to coax adapter.

COAXIAL ATTENUATORS
High performance, low cost, dc to 18 GHz
Models 8491A, B; 8492A; 8493A, B

8491A

8492A

8493A

11582A

8491A/B, 8492A, 8493A/B Fixed Attenuators

Hewlett-Packard fixed coaxial attenuators provide precision attenuation, flat frequency response, and low VSWR over broad frequency ranges at low prices. Attenuators are available in nominal attenuations of 3-dB, 6-dB and 10-dB increments from 10 dB to 60 dB. These attenuators are swept-frequency tested to insure meeting specifications at all frequencies.

11581A, 11582A, 11583A Attenuator Sets

A set of four Hewlett-Packard attenuators, 3, 6, 10 and 20 dB are furnished in a handsome walnut accessory case. In addition to the calibration stamping on the bodies of the attenuators, the set includes a calibration report. The calibration report is certified traceable to the National Bureau of Standards. The calibration report also includes accuracy of both the attenuation and the reflection coefficients at selected frequencies.

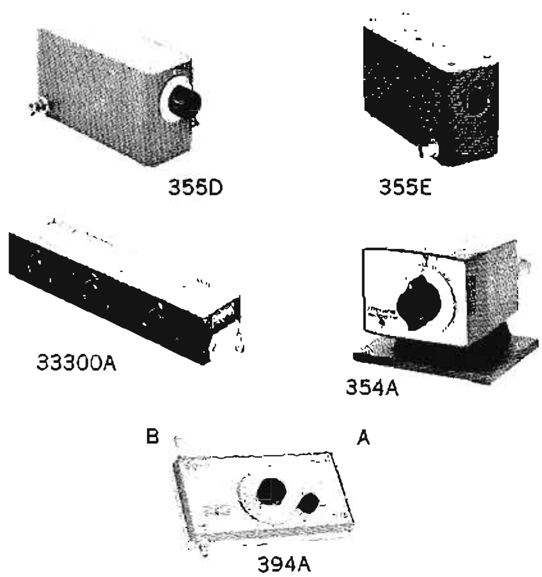
11581A (8491A's): includes 3, 6, 10, 20 dB. Price: $250
11582A (8491B's): includes 3, 6, 10, 20 dB. Price: $330
11583A (8492A's): includes 3, 6, 10, 20 dB. Price: $615

Specifications 8491A/B, 8492A, 8493A/B

	8491A		8491B			8492A			8493A		8493B		
Attenuation[1] (dB)	Option: 3, 6, 10, 20, 30, 40, 50, 60		Option: 3, 6, 10, 20, 30, 40, 50, 60			Option: 3, 6, 10, 20, 30, 40, 50, 60			Option: 3, 6, 10, 20, 30		Option: 3, 6, 10, 20, 30		
Frequency	DC - 12.4 GHz		DC - 18 GHz			DC - 18 GHz			DC - 12.4 GHz		DC - 18 GHz		
SWR[2]	DC-8 GHz 1.2	8-12.4 1.3	DC-8 GHz 1.2	8-12.4 GHz 1.3	12.4-18 GHz 1.5	DC-8 GHz 1.15	8-12.4 GHz 1.25	12.4-18 GHz 1.35	DC-8 GHz 1.2	8-12.4 GHz 1.3	DC-8 GHz 1.2	8-12.4 GHz 1.3	12.4-18 GHz 1.5
Attenuation Accuracy 3 dB	±0.3 dB		±0.3 dB			±0.3 dB			±0.3		±0.3 dB		
6 dB	±0.3 dB		±0.3 dB[3]			±0.3 dB[3]			±0.3 dB		±0.3 dB[3]		
10 dB	±0.5 dB		±0.5 dB			±0.5 dB			±0.5 dB		±0.5 dB		
20 dB	±0.5 dB		±0.5 dB[4]			±0.5 dB[4]			±0.5 dB		±0.5 dB		
30 dB	± 1 dB		± 1 dB			± 1 dB			± 1 dB		± 1 dB		
40 dB	±1.5 dB		±1.5 dB			±1.5 dB			–		–		
50 dB	±1.5 dB		±1.5 dB			±1.5 dB			–		–		
60 dB	± 2 dB		± 2 dB			± 2 dB			–		–		
Connector	N		N			APC-7			SMA		SMA		
Dimensions	2-7/16 x 13/16 inches		2-7/16 x 13/16 inches			2¾ x 13/16 inches			1-9/16 x ½ inches		1-9/16 x ½ inches		
Shipping Wt.	6 oz.		6 oz.			7 oz.			4 oz.		4 oz.		
Price (Qty. 1-4)	3-30 dB, $60 ea 40-60 dB, $85 ea		3-30 dB, $80 ea 40-60 dB, $115 ea			3-30 dB, $150 ea 40-60 dB, $185 ea			3-20 dB, $65 ea 30 dB, $70 ea		3-20 dB, $80 ea 30 dB, $85 ea		

1. Option numbers same as attenuator values; e.g., Option 003 for 3 dB, Option 006 for 6 dB, Option 010 for 10 dB etc.
2. Check data sheet for SWR slight variation of options 003 and 006 with frequency bands.
3. 6 dB option accuracy is ±0.4 dB, 12.4 - 18 GHz.
4. 20 dB option accuracy is ±1 dB, 12.4 - 18 GHz.

COAXIAL ATTENUATORS
Variable attenuators to 12.4 GHz
Models 354A, 355C-F, 393A, 394A, 33300 Series



With loads A and B in place the instrument is an attenuator.
With load A only, the instrument is a variable directional coupler.

354A step attenuator, dc to 12.4 GHz

The Model 354A is a turret-type coaxial attenuator which provides 0 to 60 dB of attenuation in 10-dB steps over the frequency range from dc to 12.4 GHz. Attenuation changes are made with a simple knob rotation: no pull-turn-push sequence is required. For bench use the attenuator is supplied with a base; however, the base is removable for easy conversion to rack mount.

355C, D, E, F manual and programmable attenuators, dc to 1 GHz

These are precision attenuators from dc-1 GHz. The 355C and D are manual while the 355E and F are programmable. 0-12 dB in 1-dB steps are provided by the 355C and E; 0-120 dB in 10 dB steps are provided by the 355D and F. Attenuator sections are inserted and removed by cam-driven microswitches. The programmable version uses a 7-pin connector which allows remote control by BCD signals.

393A, 394A attenuators, 500 MHz to 1 GHz and 1 GHz to 2 GHz

Each of these coaxial variable attenuators uses the principle of a directional coupler to achieve a wide range of attenuation over a full octave. The HP 393A covers 5 to 120 dB from 500 to 1000 MHz; HP 394A covers 6 to 120 dB from 1 to 2 GHz. With special high-power terminations they handle up to 200 watts average. Since these instruments are variable directional couplers, they are particularly useful for mixing signals while maintaining isolation.

33300/01/04/05 programmable step attenuators, dc to 18 GHz

These step attenuators provide a fast and precise means for electrically controlling the level of signal attenuation in automatic test systems. They are available in four basic configurations: 0-70 dB in 10-dB steps (33300), 0-42 dB in 6-dB steps (33301), 0-11 dB in 1-dB steps (33304) and 0-110 dB in 10-dB steps (33305). Magnetic latching solenoids (12 and 24 volts) are used to switch individual attenuation elements into and out of contact with a 50 ohm transmission line, A and B are "no contacts" and C and D are "with contacts." Specifications in the table below are for the 33300 only. Refer to data sheet for specifications of the 33301/04/05, whose prices range from $650-$950.

Specifications

Specifications	354A	355C/E	355D/F	393A	394A	33300A, B, C, D,
Mode of Operation:	Manual	355C: Manual 355E: Programmable	355D: Manual 355F: Programmable	Manual	Manual	Programmable
Attenuation:	0–60 in 10 dB steps	12 dB in 1-dB steps	120 dB in 10-dB steps	5–120 dB, variable	6–120 dB variable	0–70 dBm 10 dB steps
Frequency range:	dc-12.4 GHz	dc- 1 GHz	dc-1 GHz	.5–1 GHz	1–2 GHz	dc-18 GHz
Accuracy:	±2 dB	±0.1 dB at 1000 Hz; ±0.25 dB dc to 500 MHz; ±0.35 dB dc to 1 GHz	±0.3 dB to 120 dB at 1000 Hz; ±1.5 dB to 90 dB below 1 GHz; ±3 dB to 120 dB below 1 GHz.	±1.25 dB or ±1.75% whichever is greater	±1.25 dB or ±2.5% whichever is greater	3%, dc to 12.4 GHz 4% 12.4 to 18 GHz
Impedance:	50 ohms	50 ohms		50 ohms		50 ohms
Power dissipation:	2 watts ave., 100 peak	0.5 watt average, 350 volts peak		Approximately 200 watt, max. rating of termination must be observed		2 watt ave., 500 watts peak
Maximum SWR:	1.5, dc – 8 GHz 1.75, 8–12.4 GHz	1.2 below 250 MHz; 1.3 below 500 MHz; 1.5 below 1 GHz		2.5, 5 to 15 dB 1.5, 15 to 30 dB 1.4, 30 to 120 dB	2.5, 6 to 10 dB 1.8, 10 to 15 dB 1.6, 15 to 120 dB	refer to data sheet
Maximum Insertion Loss:	<1.5 dB	0.25 dB at 100 MHz; 0.75 dB to 500 MHz; 1.5 dB to 1 GHz		–	–	0.8 dB, dc-8 GHz 1.2 dB, 8-12.4 GHz 1.8 dB, 12.4-18 GHz
Dimensions (in.):	4 long, 4½ wide, 3⅛ in. high	6 long, 2¾ wide, 2⅝ high (152 x 70 x 67 mm)		5½ wide, 12 long, 2¾ deep. (140 x 305 x 70)		7 x 1.5 x 1.25 (178 x 38 x 32)
Weight:	net 2 lb. (1,2 kg), shipping 4 lb. (1,8 kg)	net 2 lb. (0,9 kg); shipping 3 lb. (1,4 kg)		net 6 lb. (2.7 kg), shipping 9 lb. (4.1 kg)		net 2 lb. (0,9 kg), shipping 3 lb. (1,4 kg)
	354A – $390	355C: $160 Manual 355E: $275 Programmable	355D $160 Manual 355F: $275 Programmable	393A: $725	394A: $725	33000A: $665 33000B: $665 33000C: $690 33000D: $690

WAVEGUIDE ATTENUATORS
Frequency coverage to 40 GHz
Models 382A, C and 375A

Precision Variable Attenuators

Operation of these direct-reading, precision attenuators depends on a mathematical law, rather than on the resistivity of the attenuating material. Accurate attenuation from 0 to 50 dB (0 to 60 dB for S382C) is assured regardless of temperature and humidity. The instruments can handle considerable power and feature large, easily read dials. In addition, the S382C achieves both long electrical length and short physical dimensions through dielectric loading. The result is an S-band attenuator which is only 25¼ inches long and yet is more accurate than previously available units.

HP Model	S382C	J382A	H382A	X382A	P382A	K382A[1]	R382A[1]
Frequency range (GHz):	2.6-3.95	5.3 - 8.2	7.05 - 10.0	8.2 - 12.4	12.4 - 18.0	18.0 - 26.5	26.5 - 40.0
Waveguide size (in): (EIA):	3 x 1½ WR284	1½ x ¾ WR137	1¼ x ⅝ WR112	1 x ½ WR90	.702 x .391 WR62	½ x ¼ WR42	.360 x .220 WR28
Power handling capacity, watts, average continuous duty:	10	10	10	10	5	2	1
Size length, in. (mm): height, in. (mm): depth, in. (mm):	25¼ (641) 6 (152) 8 (203)	25 (635) 7⅞ (200) 6-3/16 (157)	20 (508) 7-15/16 (202) 6½ (165)	15⅝ (397) 7⅝ (194) 4-11/16 (119)	12½ (318) 7¾ (197) 4¾ (121)	7⅝ (194) 6⅛ (156) 4¾ (121)	6⅜ (162) 6⅛ (156) 4¾ (121)
Weight net, lb (kg): shipping, lb (kg):	18 (8,1) 22 (9,9)	13 (5,9) 17 (7,7)	11 (5,0) 15 (6,8)	6 (2,7) 8 (3,6)	5 (2,3) 8 (3,6)	3 (1,4) 6 (2,7)	3 (1,4) 6 (2,7)
Price:	$1800	$700	$675	$425	$500	$725	$800

For all 382A Models

Incremental attenuation range: 0 to 50 dB.

Residual attenuation: less than 1 dB.

Reflection coefficient: less than 0.07 (1.15 SWR, 23.1 dB return loss).

Accuracy: ±2% of reading in dB, or 0.1 dB, whichever is greater. Includes calibration and frequency error.

For Model S382C

Calibrated attenuation range: 0 to 60 dB (above residual attenuation).

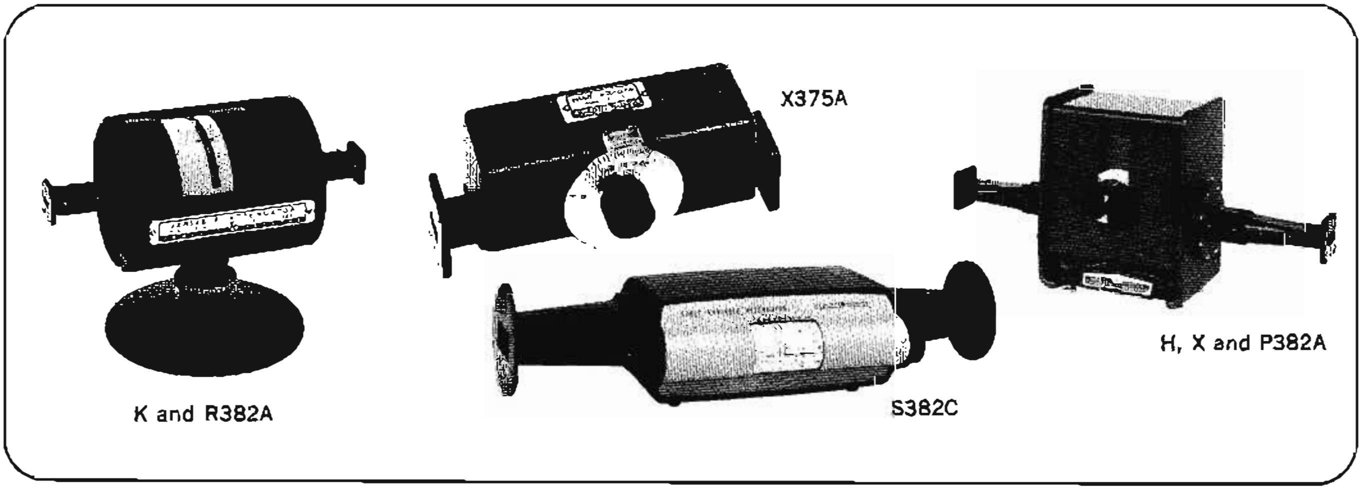
Residual attenuation: less than 1 dB.

Accuracy: ±1% of reading in dB, or 0.1 dB, whichever is greater, from 0 to 50 dB; ±2% of reading above 50 dB; includes calibration and frequency error.

Reflection coefficient: less than 0.091 (1.2 SWR, 20.8 dB return loss), 2.6 to 3 GHz; less than 0.07 (1.15 SWR, 23.1 dB return loss), 3 to 3.95 GHz.

Degree dial: 0 to 90°; calibrated in 0.01° increments.

[1] Circular flange adapters: K-band (UG-425/U) 11515A, $60 each; R-band (UG-381/U) 11516A, $50 each.



General-Purpose Attenuators

Variable flap attenuators provide a simple, convenient means of adjusting waveguide power level or isolating source and load. They consist of a slotted section in which a matched resistive strip is inserted. The degree of strip penetration determines attenuation. A dial shows average reading over the frequency band, and a shielded dust cover reduces external radiation and eliminates hand capacity effects. Attenuation is variable from 0 to 20 dB. Dial calibration is accurate within ±1 dB from 0 to 10 dB, ±2 dB from 10 to 20 dB. Maximum reflection coefficient is 0.07 (1.15 SWR, 23.1 dB return loss).

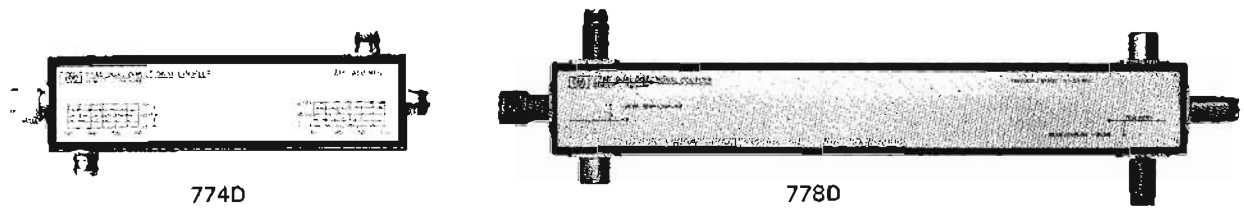
Specifications, 375A

HP Model	Frequency (GHz)	Power dissipation (watts)	Length (in.)	Length (mm)	Fits waveguide size (in.)	Price
X375A	8.2 - 12.4	2.0	7-4/5	198	1 x ½	$225
P375A	12.4 - 18.0	1.0	7¼	184	.702 x .391	$250

BROADBAND COAX COUPLERS

Multi-Octave coverage with high directivity

774D-778D



774D　　778D

774D-777D Dual Directional Couplers

The economical 774D-777D couplers cover frequency spreads of more than two-to-one, each centered on one of the important VHF/UHF bands. With their high directivity, these couplers are ideal for reflectometer applications. Furthermore, the close tracking of the auxiliary arms makes these couplers particularly useful for reflectometers driven by externally-leveled sweep oscillators such as HP8690B and 8620A/B. The forward signal is detected and used to level the output of the sweep oscillator while the reflected signal, after detection is applied to a display device. Changes in the leveled power due to the coupling variation in the forward arm are virtually cancelled by a similar coupling variation in the reverse arm.

778D Dual Directional Coupler

The HP778D is a 20-dB dual directional coupler with a frequency range of 100 MHz to 2 GHz. High directivity and close tracking (typically 0.7 dB and 4°) of the auxiliary arms make it ideal for reflectometer measurements of complex reflection coefficient. Maximum errors in such measurements are:

Freq. Range (GHz)	Maximum Magnitude Error $\Delta\Gamma_L$	
	Swept Frequency	Fixed Frequency
0.1–1	$\pm(0.015+0.02\,\lvert\Gamma_L\rvert+0.05\,\lvert\Gamma_L\rvert^2)$	$\pm(0.015+0.05\,\lvert\Gamma_L\rvert^2)$
1–2	$\pm(0.025+0.02\,\lvert\Gamma_L\rvert+0.05\,\lvert\Gamma_L\rvert^2)$	$\pm(0.025+0.05\,\lvert\Gamma_L\rvert^2)$

Maximum phase error $= \pm \sin^{-1}(\Delta\Gamma_L/\Gamma_L)$.
$\lvert\Gamma_L\rvert$ = reflection coefficient of unknown.

Errors include directivity, source match, and tracking, but do not include any detection errors.

The 778D is provided with type "N" connectors. APC-7 is available as an option, and adapters to other connectors are available on request.

Specifications 774D, 775D, 776D, 777D, 778D

HP Model	Frequency Range	Coupling Attenuation	Coupling Variation	Directivity	SWR	Max Input	Connector	Length in (mm)	Price
774D	215–450 MHz	20 dB	±1 dB	40 dB	1.15 pri 1.2 aux	50 W avg, 500 W pk,	pri: type N, one male, one female	9-1/16 (230)	$300
775D	450-940 MHz	20 dB	±1 dB	40 dB	1.15 pri 1.12 aux	0.1 sec duty cycle		9-1/16 (230)	$325
776D	940–1900 MHz	20 dB	±1 dB[1]	40 dB	1.15 pri 1.2 aux		aux: type N, female	6-5/16 (161)	$325
777D	1900–4000 MHz	20 dB	±0.4[1]	30 dB	1.2 pri 1.3 aux			8⅞ (225)	$350
778D	100–2000 MHz	20 dB nominal	±1 dB[2]	Reflected port: 36 dB, 0.1-1 GHz, 32 dB, 1-2 GHz Inc. port: 30 dB, 0.1-2 GHz	1.1 all	50 W avg, 10 kW pk	Pri line[3] N-male input, N-female output Aux arms: N-female	16¾ (425)	$450 Opt 011: add $25 Opt 012 no extra charge

[1] Aux arm tracking: <0.3 dB for 776D. <0.5 dB for 777D.
[2] Auxiliary outputs typically track within 0.7 dB and 4°.
[3] Option 011: APC-7 output, N-female input.
Option 012: N-male output, N-female input.

DIRECTIONAL COUPLERS

High directivity, low SWR

779D, 790 Series, 780 Series

779D directional coupler

Representing the latest achievement in broadband coaxial couplers, the HP 779D spans more than two octaves from 1.7 to 12.4 GHz with excellent directivity. With increased coupling factor (typically 24 dB), the 779D is useful down to 500 MHz. Upper frequency usefulness extends to 18 GHz with directivity reduced to about 15 dB.

The 779D is normally supplied with type N connectors on all ports. On special order, a precision APC-7 connector can be supplied on any, or all, ports.

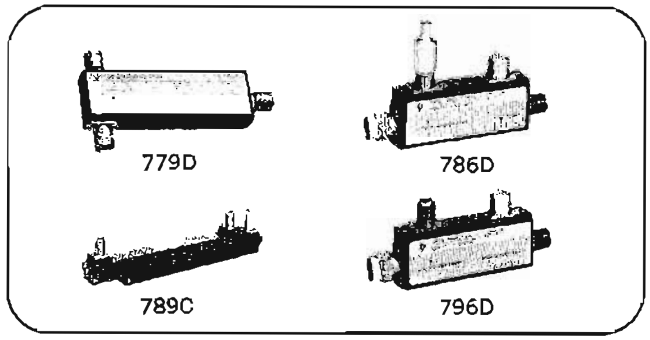
790 directional couplers

The 790 directional couplers are ultra-flat, high directivity couplers which are ideal for power-monitoring applications in coaxial systems. Output coupling (ratio of output power from main and auxiliary arms) is specified rather than coupling factor. Thus, no correction factor is required to account for insertion losses in the main arm.

780 directional detectors

The 780 series directional detectors are directional couplers with built-in crystal detectors. The couplers have flat frequency response and good directivity, while the detectors have good frequency response plus high sensitivity. The configuration of the directional detector reduces the number of ambiguities over the standard system of separate coupler and detector and makes possible tighter correlation between main-arm power and detected signal.

The directional detector is well suited for sweep oscillator leveling and can also be used to monitor power with a voltmeter or oscilloscope.



Specifications, 779D, 790 Series

HP Model	Frequency range (GHz)	Mean output coupling (dB)[1]	Output coupling variation (dB)[2]	Directivity (dB)[2]	Equiv. source match[2,3]	Max. primary line SWR	Max. aux. arm SWR	Max. input (W)	Max. insertion loss (dB)[4]	Length (in)	Length (mm)	Shipping weight (lb)	Shipping weight (kg)	Price
779D	1.7 to 12.4	20 ±0.5	<=0.75	30,1.7-4 GHz,26, 4-12.4GHz	1.2	1.2	1.2	50	0.5	7¼	196	3	1.4	$550
796D	0.96 to 2.11	20 ±0.5	±0.2	30	1.13	1.15[2]	1.20[2]	50	0.4	6	152	2	0.9	$275
797D	1.9 to 4.1	20 ±0.5	±0.2	26	1.16	1.15[2]	1.25[2]	50	0.5	4⅞	124	2	0.9	$300
798C	3.7 to 8.3	10 ±0.3	±0.3	20	1.25	1.20	1.20	10	0.8	4⅞	124	2	0.9	$325
For all models: RF connectors: primary line: type N, one male (input), one female; auxiliary arm: type N female.[5]														

[1]Difference in dB between power out of primary line and auxiliary arm.
[2]Swept-frequency tested.
[3]The apparent SWR at the output port of a directional coupler when it is used in a closed-loop leveling system.
[4]Includes loss due to coupling.
[5]Type N connectors mate compatibly with connectors whose dimensions conform to MIL-C-39012 or MIL-C-71.

Specifications, 780 Series

HP Model	Frequency range (GHz)	Freq. resp. (dB)[1]	Low-level sens. (μV/μW)	Directivity (dB)	Equiv. source SWR[2]	Max. SWR	Max. input (W, peak or avg.)	Max. insertion loss (dB)	Length (in)	Length (mm)	Shipping weight (lb)	Shipping weight (kg)	Price
784A	1.7 to 12.4	±1.0	>5	13	1.25	1.4	1	1.25	6¼	159	2	0.9	$625
786D	0.96 to 2.11	±0.2	>4	30	1.13	1.15	10	0.4	6	152	2	0.9	$300
787D	1.9 to 4.1	±0.2	>4	26	1.16	1.15	10	0.5	4⅞	124	2	0.9	$325
788C	3.7 to 8.3	±0.3	>40	20	1.25	1.20	1	0.8	4⅞	124	2	0.9	$350
789C	8.0 to 12.4	±0.5	>20	17	1.25	1.40	1	1.2	11⅝	295	3	1.4	$550

[1] Includes coupler and detector variation with frequency as read on a meter calibrated for square-law detectors (e.g., HP 415E SWR Meter).
[2] The apparent reflection coefficient at the output of an RF generating system, using a directional detector in a closed-loop leveling system.
[3] Type N connectors mate compatibly with connectors whose dimensions conform to MIL-C-39012 or MIL-C-71.

For all models

Detector output impedance: 15 kΩ max. shunted by approx. 10 pF.

Detector element: supplied.

Noise: <200 μV peak-to-peak with CW power applied to produce 100 mV output.

Detector output polarity: negative.

Detector output connector: BNC female.

RF connectors:[3] Type N, one male (input), one female (789C: both female).

Options

002. Furnished with load resistor for optimum square law characteristics at 24°C (75°F), <±0.5 dB variation from square law over a range of at least 30 dB from low level up to 50 mV peak output (working into external load >75 kΩ); sensitivity typically one-fourth of unloaded sensitivity; add $20.

003. Positive polarity detector output; no additional charge.

DIRECTIONAL COUPLERS

Easy-to-use, precision instruments

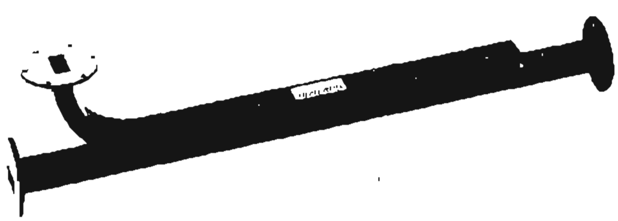
Model 752A,C,D

The HP 752 Directional Couplers are important tools in waveguide measurements. They can be used to monitor power, measure reflections, mix signals, or isolate signal sources or wavemeters.

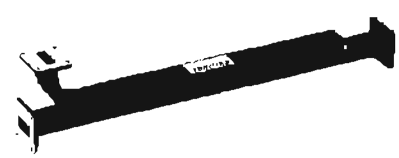
Each coupler has an overall directivity of better than 40 dB (including reflection from built-in termination and flange) over its entire range. Performance characteristics are unaffected by humidity, temperature or time, thus making these units especially useful in microwave "standards" measurements. Coupling factors are 3, 10 and 20 dB; mean coupling accuracy is ±0.4 dB (±0.7 dB for K- and R-bands); and coupling variation vs frequency is ±0.5 dB (±0.6 dB for R752D).

Used together and connected back to back, two couplers are most useful with the HP 8620A Sweep Oscillator (see Signal Sources) in broadband reflection and SWR measurements. One directional coupler samples power traveling toward the load, and the detected sample can be used to maintain a constant forward power. The output of the auxiliary arm of the second coupler, which samples power reflected from the load, is then a direct indication of reflection coefficient and swr. After detection, this signal can be viewed on an oscilloscope or permanently recorded on an x-y recorder. The HP 424A Series Crystal Detectors are ideal for use with the 752 couplers.

In the system described above, the variation in coupling with frequency of the two couplers tends to cancel. This cancellation effectively improves the leveling of the signal source and increases the accuracy of the measurement. For applications in which the actual variations in source output must be minimized, matched pairs of couplers for the leveling loop are available on special order. The pair comprises a 3- and 10- or 20-dB coupler. The 3-dB coupler is connected to the auxiliary arm of the 10- or 20-dB coupler, reducing coupling variation to less than ±0.2 dB. Swept-frequency techniques are described in detail in Application Note 65, available from any HP field office.



J752A



X752A

Specifications, 752 Series

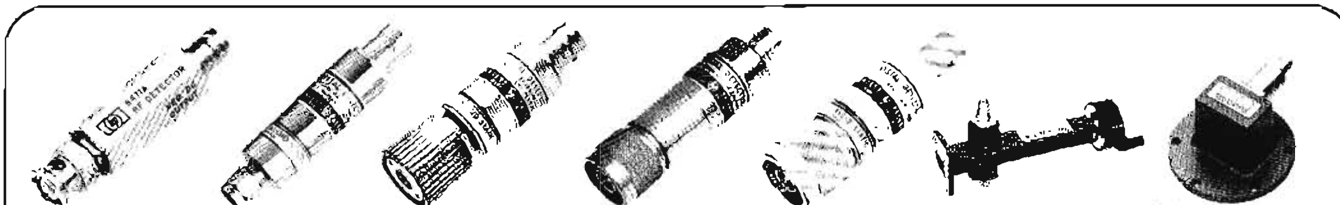
Band[1,2] (prefix)	Frequency (GHz)	Fits waveguide size (in)	Mean coupling accuracy (dB)[3,4]	SWR[5,6] main guide		Average power aux. guide load (W)	Length (in)			Shipping weight		Price
				752A	752C,D		A	C	D	(lbs)	(kg)	
J*	5.85–8.2	1½ x ¾	±0.4	1 1	1.05	1	26½	25-9/16	25-9/16	8	3,6	$400
H	7.05–10	1¼ x ⅝	±0.4	1 1	1.05	1	18⅝	17½	17½	4	1,8	$300
X	8.2–12.4	1 x ½	±0 4	1 1	1.05	1	16–11/16	15–11/16	15–11/16	3	1,4	$200
P	12.4–18	.702 x 391	±0.4	1 1	1 05	1	13¾	12¼	12¼	2	0,9	$225
K†	18–26 5	½ x ¼	±0 7	1.1	1 05	½	10⅝	9–15/16	9–15/16	2	0,90	$275
R†	26 5–40	.360 x .220	±0.7	1.1	1.05	½	11⅝	8⅜	8–23/32	2	0,90	$300

[1]When ordering, specify suffix letter to indicate nominal coupling: A for 3 dB, C for 10 dB, D for 20 dB (example: X-band, 3 dB coupling, Model X752A).
[2]Directivity is at least 40 dB; swept-frequency tested.
[3]Mean coupling is the average of the maximum and minimum coupling values in the rated frequency range.
[4]Coupling variation over rated frequency range is not more than ±0.5 dB about mean coupling (±0.6 dB for R752D).
[5]Auxiliary arm swr is 1.15 (1.2 for P-, K- and R-band units).
[6]Swept-frequency tested.
*J752 Couplers operate to 5.3 GHz with reduced performance.
†Circular flange adapters: K-band (UG-425/U), HP 11515A, $60 each; R-band (UG-381/U), HP 11516A, $50 each.

CRYSTAL DETECTORS

Flat response, high sensitivity, low SWR

Models 8470A, 8471A, 8472A, 423A, 424A, 420A/B, 422A



8471A 8472A 8470A 420A/B 423A X485B J424A

The HP 8470A and 8472A extend the frequency range of coaxial crystal detectors to 18 GHz. Like the 423A and 424A Crystal Detectors, the 8470A and 8472A combine extremely flat frequency response with high sensitivity and low SWR, making them extremely useful as the detecting element in closed-loop leveling systems. Matched pairs are available for applications requiring the utmost in detector tracking, and all but the 8472A can be supplied with video loads for optimum conformance to square law over a range of at least 30 dB.

The 422A Crystal Detectors are convenient waveguide detectors which cover K- and R-bands. They have a dynamic range of 40 dB or more, making them suitable for reflectometer as well as general-purpose applications.

The 420A is a low-cost crystal detector which covers the coaxial range from 10 MHz to 12.4 GHz, making it ideal for general-purpose video detection. The 420B is essentially the same unit as the 420A with the addition of a selected video load for optimum square-law characteristics in the 1 to 4 GHz range.

X485B Detector Mount

The X485B Detector Mount permits the accurate matching of waveguide sections to a bolometer element. The mount is tuned by a variable short, can be used with a barretter or, where SWR is not critical, with a silicon crystal.

Specifications, X485B[1]

HP Model	Frequency range (GHz)	Maximum SWR[2]	Fits waveguide size (in.)	Fits waveguide size (EIA)	Length (in.)	Length (mm)	Price
X485B[3]	8.2 - 12.4	1.25	1 x ½	WR90	6-7/16	163	$150

[1]Detector elements are not supplied
[2]With Weinschel 1180P-8 barretter
[3]May use 1N21 or 1N23 crystal for maximum detection sensitivity where SWR is not critical

Specifications

HP Model	Frequency Range GHz	Frequency Resp. (dB)	Low-Level Sensitivity (mV/μW)	Maximum SWR	RF Input	Matched Pair Available	Square-Law Load Available	Length (in.)	Length (mm)	Shipping Weight (lb.)	Shipping Weight (kg)	Price
8471A	100 KHz–1.2 GHz	±0.6; typ ±0.1/100 MHz	>0.35	Typically 1.3	BNC Male	No	No	2¾	70	1	0.5	$ 50
423A	0.01-12.4	±0.2/octave to 8 GHz; ±0.5 overall	>0.4	1.2 to 4.5 GHz; 1.35, 4.5-7 GHz 1.5, 7-12.4 GHz	Type N Male	Yes[1]	Yes[2]	2-15/32	63	0.5	0.2	150
420A	.01-12.4	±3.5 dB	>0.1	3.0	Type N Male	No	No	3	76	0.5	0.2	65
420B	1–4 GHz with load	±3	>0.05	3.0	Type N Male	Yes[1]	Yes[2]	3	76	0.5	0.2	95
8470A	0.01-18	±0.2/octave to 8 GHz; ±0.5 to 12.4 GHz ±1 Overall	>0.4	1.2 to 4.5 GHz; 1.35 to 7 GHz; 1.5 to 12.4 GHz; 1.7 to 18 GHz	APC-7	Yes[1]	Yes	2½	64	1	0.5	190
8472A	0.01-18	Same as 8470A	>0.4	Same as 8470A	SMA Male	Yes[1]	No	2½	64	0.2	0.1	175
8472A Opt. 100	.01–18	Same as 8470A	>0.4	Same as 8470A	OSM Male	Yes[1]	No	2-1/16	53	0.2	0.1	190
S424A	2.60–3.95	±0.2	>0.4	1.35		Yes[3]	Yes[2]	2-7/16	62	2	0.9	210
G424A	3.95–5.85	±0.2	>0.4	1.35		Yes[3]	Yes[2]	2-1/16	52	2	0.9	200
J424A	5.30–8.20	±0.2	>0.4	1.35	Wave-	Yes[3]	Yes[2]	1⅞	48	1	0.5	200
H424A	7.05–10.0	±0.2	>0.4	1.35	Guide	Yes[3]	Yes[2]	1-9/16	40	0.6	0.3	190
X424A	8.20–12.4	±0.3	>0.4	1.35	Cover	Yes[2]	Yes[2]	1⅜	35	0.5	0.2	170
M424A	10.0–15.0	±0.5	>0.3	1.5	Flange	Yes[2]	Yes[2]	1	25	0.5	0.2	290
P424A	12.4–18.0	±0.5	>0.3	1.5		Yes[3]	Yes[2]	15/16	24	0.4	0.2	210
K422A[5]	18.0–26.6	±2	x0.3	2.5		Yes[4]	Yes[2]	2	51	0.6	0.3	350
R422A[5]	26.5–40.0	±2	x0.3	3		Yes[4]	Yes[2]	2	51	0.6	0.3	350

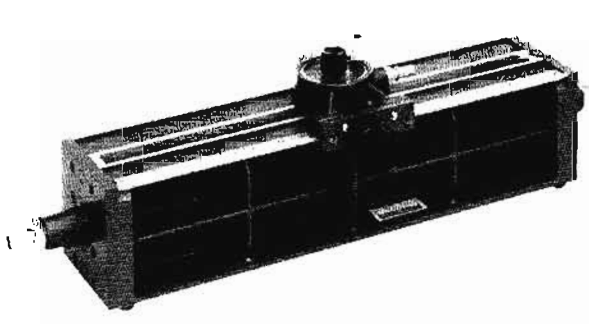
For all models—**Maximum input:** 100 mW peak or average, 8471A: 3 V rms, 4.2 V pk). **Detector element:** supplied. **Output polarity:** negative (positive output available: for 423A, 8470A, 424A specify Option 003—no additional charge; for 8471A specify Option 004—no additional charge; for 8472A by special order only). **Output connector:** BNC female (for OSSM on 8472A, specify Option H01 add $15/unit).

[1]Frequency response characteristics (excluding basic sensitivity) track within ±0.2 dB per octave from 10 MHz to 8 GHz, ±0.3 dB from 8 to 12.4 GHz, and (8470A and 8472A) ±0.6 dB from 12.4 to 18 GHz; specify Option 001, add $20 per unit ($40 per pair). (8472A, available on special order.)
[2]<±0.5 dB variation from square law up to 50 mV peak output into >75 kΩ; sensitivity typically >0.1 mV/μW; specify Option 002; add $20.
[3]Frequency response characteristics (excluding basic sensitivity) track within ±0.2 dB for S-, G-, J- and H-band units, ±0.3 dB for X-band units, and ±0.5 dB for M- and P-band units; specify Option 001; add $20 per unit ($40 per pair).
[4]Matched pair of units fitted with square-law loads. Frequency response characteristics (excluding basic sensitivity) track within ±1 dB for power levels less than approx. 0.05 mW; specify Option 001; add $40 per unit ($80 per pair)
[5]Circular flange adapters: 11515A (UG-425/U) for K-band, $60 each; 11516A (UG-381/U) for R-band, $50 each.

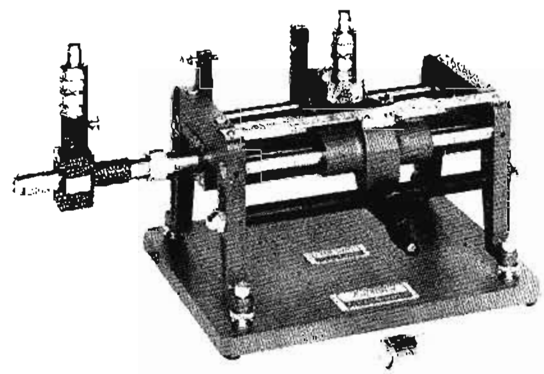
SLOTTED LINES

Precision tools for measurements to 40 GHz

Models 805C, 809C, 810B, 816A, 817A, 444A, 447B



805C



817A

Slotted Lines Detectors

Hewlett-Packard offers a complete line of slotted lines, detectors and carriages covering the frequency range of .5-40 GHz. A summary of this product group is presented on the following three pages.

805C Coaxial Slotted Line, 0.5-4 GHz

Model 805C is a coaxial slotted line with an integral probe circuit tunable from 500 to 4,000 MHz. The slotted line consists of two parallel planes and a rigid center conductor. This configuration results in negligible slot radiation, minimum sensitivity to variation in probe depth or centering, and greater strucutral stability.

Specifications, 805C

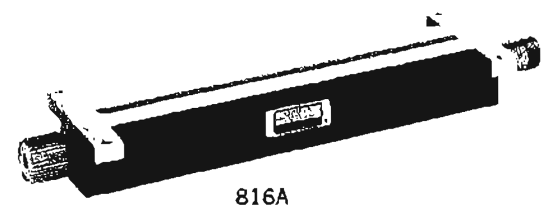
Frequency range: 500 to 4,000 MHz.
Impedance: 50Ω.
Residual SWR: less than 1.04:1.
Connectors: type N, one male/female.
Calibration: metric, cm and mm; vernier reads to 0.1 mm.
Detector probe: tunable; detector may be 1N21B crystal (supplied) or 821 series barretter or selected 1/100-amp instrument fuse.
Accessories furnished: 11511A shorting jack; 11512A shorting plug.
Price: HP 805C, $1000.

817A Coaxial Swept Slotted Line System, 1.8-18 GHz

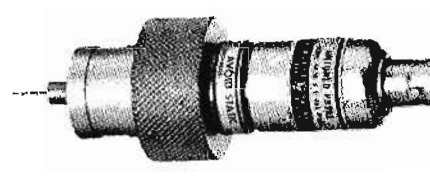
The 817A is a fully tested, complete swept slotted line system that enables you to make accurate swept-frequency SWR measurements in coax from 1.8 to 18 GHz. The 817A system consists of an 816A Coaxial Slotted Line, an 809C Carriage with baseplate, and a 448A Slotted Line Sweep Adapter.

Specifications, 817A

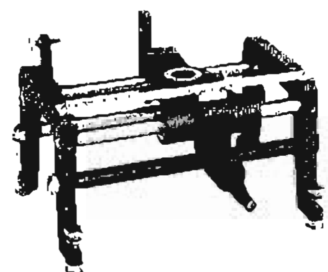
Frequency range: 1.8 to 18 GHz.
Impedance: 50Ω ±0.2Ω.
Output connector: APC-7 or type N female, depending upon which end of the 816A is connected to the load.
Residual SWR:
APC-7 connector: 1.02-1.04 depending on frequency coverage.
Type N connector: 1.04-1.06 depending on frequency coverage.
Accessories furnished: 11512A N male short, 11565A APC-7 short.
Dimensions (maximum envelope): 13½" long, 7" wide, 7" high (343 x 178 x 178 mm).
Weight: net, 15 lbs (6,5 kg); shipping 20 lbs (9,0 kg).
Price: Model 817A, $1100.
Option 022: type N male connector in lieu of APC-7, less $15.
Option H03: operation with 8755 series frequency response test sets, less $100.



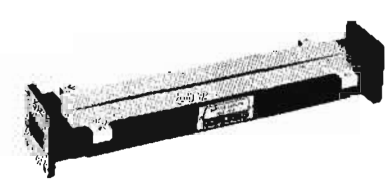
816A



447B



809C



X810B

444A

809C Carriage

The 809C Carriage operates with the 816A Coaxial Slotted Section and four 810B Waveguide Slotted Sections. Four detectors can be used with the 809C: the 442, 444A, 447B, and 448A. The carriage has a centimeter scale with a vernier reading to 0.1 mm, and provision is made also for mounting a dial gauge if more accurate probe position reading is required.

Price: 809C, $300.

816A Coaxial Slotted Section, 1.8-18 GHz

(Used with 809C Carriages and 447B or 448A Detector Probes)

The 816A consists of two parallel planes and a rigid center conductor. This configuration virtually eliminates radiation and minimizes the effect of variation in probe penetration and centering. It is fitted with one APC-7 and one type N female connector.

Specifications, 816A

Frequency: 1.8-18 GHz.

Residual VSWR:

APC-7 1.02-1.04 depending on frequency coverage.

type N 1.04-1.06 depending on frequency coverage.

Length: 9¾ inches (248 mm).

Weight: net, 1½ lbs (0,68 kg); shipping 3 lbs (1,4 kg).

Accessories furnished: 11512A type N male short; 11565A APC-7 short.

Price: HP 816A, $350.

Option 011: both connectors APC-7, add $25.

810B Slotted Sections, 5.3-18 GHz

(Used with 809C Carriage and 442B/444A Detector)

Waveguide slotted line measurements in the frequency range 5.3-18 GHz are made using the 810B Slotted Section, the 809C Carriage and 444A Probe or 440A plus 442B Probe combination.

Specifications, 810B

HP Model	Frequency range (GHz)	Fits Waveguide size EIA	Equivalent	Price
J810B	5.30–8.20	WR137	UG441/U	$275
H810B	7.05–10.0	WR112	UG138/U	215
X810B	8.20–12.4	WR90	UG135/U	205
P810B	12.4–18.0	WR62	UG419/U	225

444A Untuned Probe, 2.6-18 GHz

The 444A Untuned Probe, for use with HP 810B Waveguide Slotted Sections, consists of a crystal, plus a small antenna in convenient housing. The probe is held in position by friction or may be fixed by a locking ring. No tuning is required and sensitivity equals or exceeds many elaborate single and double-tuned probes. The 444A fits the 809C Carriage or other carriages with a ¾ inch (19 mm) mounting hole. Frequency range is 2.6 to 18 GHz.

Accessory furnished: 11506A Probe Extension Kit.

Price: HP 444A, $65.

447B Detector

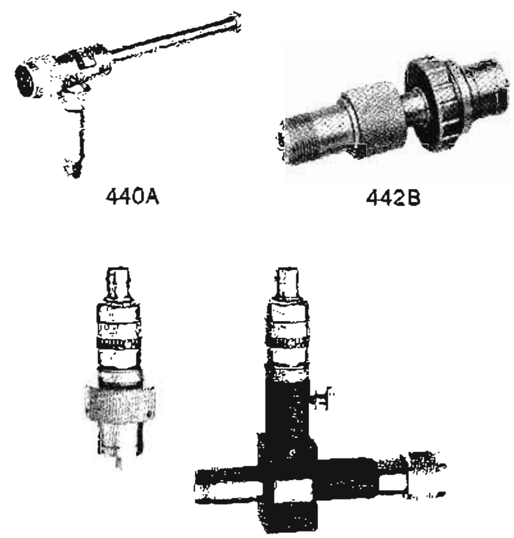
Model 447B consists of a crystal diode detector plus a small antenna probe for sampling energy in HP 816A Coaxial Slotted Lines. The untuned probe is extremely sensitive over its frequency range of 1.8 to 18 GHz. Such performance is achieved through the use of a unique, easily replaced diode package developed by Hewlett-Packard. The 447B fits HP 809C Carriage or other carriages with a ¾″ (19 mm) mounting hole.

Price: HP 447B, $125.

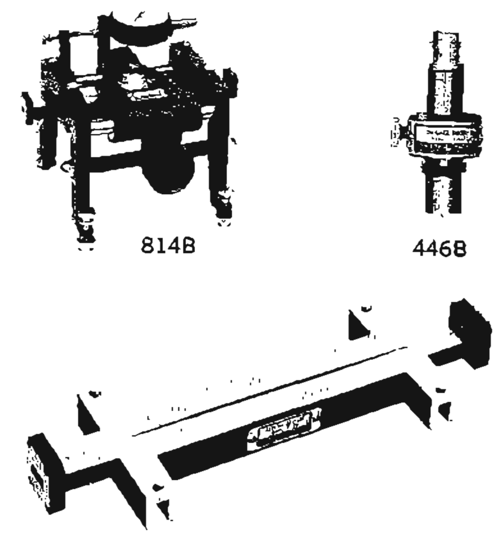
SLOTTED LINES

Precision tools for measurement to 40 GHz

Models 440A, 442B, 446B, 448A, 814B, K815B



440A 442B 448A



814B 446B K815B

440A Detector Mount

The 440A is a tunable mount used for detecting RF energy in coaxial systems or in conjunction with the HP 442B in waveguide or coaxial slotted sections. Detector (not supplied) can be a 1N21 or 1N23 Crystal or 821 Series Barretter.

Price: 440A, $125.

442B Broadband Probe, 2.6-12.4 GHz

Model 442B is a probe whose depth of penetration into a slotted section is variable. Held in position by friction, it may be fixed in place by a locking ring. Sampled RF appears at a type N jack. It can be connected to a 440A Detector Mount to form a sensitive and convenient tuned RF detector for HP 810B Waveguide Slotted Sections. The 442B fits the 809C Carriage. Frequency range is 2.6 to 12.4 GHz.

Price: HP 442B, $60.

448A Slotted Line Sweep Adapter, (detector probe) 1.8-18 GHz

The 448A consists of a short slotted line and two matched detectors with adjustable probes. One detector levels the signal source, the other monitors the standing waves in the 816A.

Specifications, 448A

Frequency range: 1.8-18 GHz.

Connectors: type N, one male/female.

Weight: net, 7 oz (0,20 kg); shipping, 14 oz (0,40 kg).

Price: 448A, $400.

815B Slotted Section, 18-40 GHz

(Used with 814B Carriage and 446B Detector)

The 815B Waveguide Slotted Sections are designed to fit the 814B Carriage. Like the lower-frequency slotted sections, each 815B is precision-manufactured, broached and checked with precision gauges for careful control of guide wavelength. The slot is tapered to insure a low SWR.

Specifications, 815B

	K815B	R815B
Frequency range (GHz):	18 to 26.5	26.5 to 40
Residual SWR:	1.01	1.01
Overall length:	7-9/16″ (192 mm)	7-9/16″ (192 mm)
Price:	$675	$700

* Circular flange adapters: K-band (UG425/U) 11515A, $60 each; R-band (UG381/U) 11516A, $50 each.

814B Carriage

The HP 814B Carriage is designed for use with the HP K815B (18 to 26.5 GHz) and R815B (26.5 to 40 GHz) Waveguide Slotted Sections and HP 446B Untuned Probe. The carriage is equipped with a dial indicator for accurate reading. Slotted sections are easily interchanged.

Price: HP 814B, $660.

446B Broadband Detector

The HP 446B is a broadband detector and probe which consists of a modified 1N53 silicon diode in a carefully designed shielded housing. No tuning is required, and probe penetration may be varied quickly and easily. Designed for use with the 814B Carriage, the 446B has a frequency range of 18 to 40 GHz.

Price: HP 446B, $275.

TERMINATIONS
Loads and shorts for measurements to 40 GHz
Models 905; 907-911; 914; 920; 923; 930

MICROWAVE TEST EQUIPMENT

905A 908A 11512A

905A, 907A, 911 Sliding Loads

The 905A, 907A and 911A are movable 50Ω, low reflection loads for precision measurements. The 905A and 907A are supplied with three interchangeable connectors, N-male, N-female and APC-7. The 911A is supplied with SMA male and female.

905A, 907A, 911A Specifications

HP Model	Frequency range	Load SWR	Power rating	Length in. (mm)	Shipping weight	Price
905A	1.8-18 GHz	1.05	1W avg, 5kW pk	17¼ (440)	3 lb (1,4 kg)	$300
907A	1-18 GHz	1.1, 1-1.5 GHz; 1.05, 1.5-18 GHz	1W avg, 5kW pk	30⅝ (778)	9 lb (4,1 kg)	$450
911A	2-18 GHz	1.1, 2-4 GHz; 1.05, 4-18 GHz	1W avg, 5kW pk	14⅞ (380)	3 lb (1,4 kg)	$250

908A, 909A Terminations

The 908A and 909A Terminations are low-reflection loads for terminating 50Ω coaxial systems in their characteristic impedance:

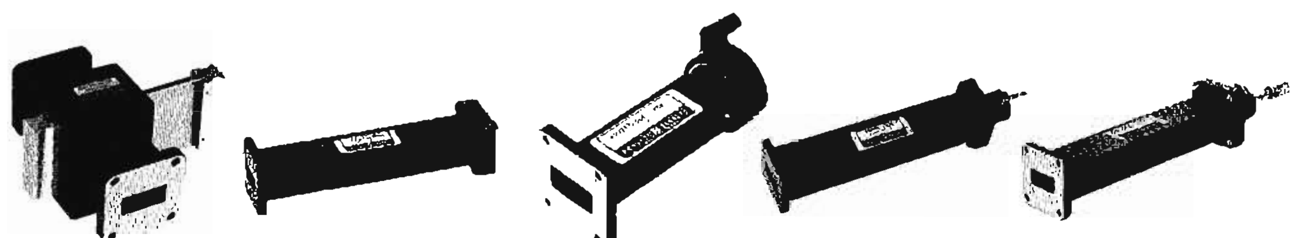
908A 909A Specifications

HP Model	Frequency Range	Impedance	SWR	Power Rating	Connector	Price
908A	dc–4 GHz	50 ohms	1.05	½ W avg, 1 kW pk	N male	1 to 4, $45 ea. 5 to 9, $39 ea. 10 to 24, $35 ea.
909A	dc–18 GHz	50 ohms	1.05, 0–4 GHz 1.1, 4–12.4 GHz 1.25, 12.4–18 GHz	2 W avg, 300 W pk	APC-7	1 to 4, $85 ea. 5 to 9, $79 ea. 10 to 24, $75 ea.
909A Option 012 and Option 013	dc–18 GHz	50 ohms	1.06 0–4 GHz 1.11, 4–12.4 GHz 1.3, 12.4–18 GHz	2 W avg 300 W pk	Opt. 012 N male Opt. 013 N female	deduct $15

11511A, 11512A, 11565A Shorts

These shorts are used for establishing measurement planes and known reflection phase and magnitude in 50Ω coaxial systems.

Price: 11511A N-female $10; 11512A N-male $10, 11565A APC-7 $25.



X930A X910B H920A X914B X923A

910A-B, 914A Waveguide Terminations

The 910A-B are fixed termination for waveguide systems. The 914A-B are similar to the 910A-B, except that its absorptive element is movable and a lockable plunger controls the position of the element.

910A/B, 914A/B Specifications

Model	Frequency Range (GHz)	SWR	Power Ratings	Type	Waveguide Size (EIA)	Price
J910A	5.3–8.2	1.02	1 watt	fixed	WR137	$ 95
H910A	7.05–10.0	1.02	1 watt	fixed	WR112	80
X910B	8.2–12.4	1.015	1 watt	fixed	WR90	55
P910A	12.4–18	1.02	1 watt	fixed	WR62	50
J914A	5.3–8.2	1.01	2	sliding	WR137	225
H914A	7.05–10.0	1.01	1	sliding	WR112	200
X914B	8.2–12.4	1.01	1	sliding	WR90	95
P914A	12.4–18	1.01	½	sliding	WR62	175
K914B	18–26.5	1.01	½	sliding	WR42	350
R914B	26.5–40	1.01	½	sliding	WR28	400

920A-B, X923A, X930A Shorts

The 920A-B are movable shorts, adjustable through at least half a wavelength at the low end of the band. The X923A is also a movable short, but is adjustable through about two wavelengths at 8.2 GHz. The X930A is a removable short. SWR is less than 1.02 in "open", greater than 125 in "short".

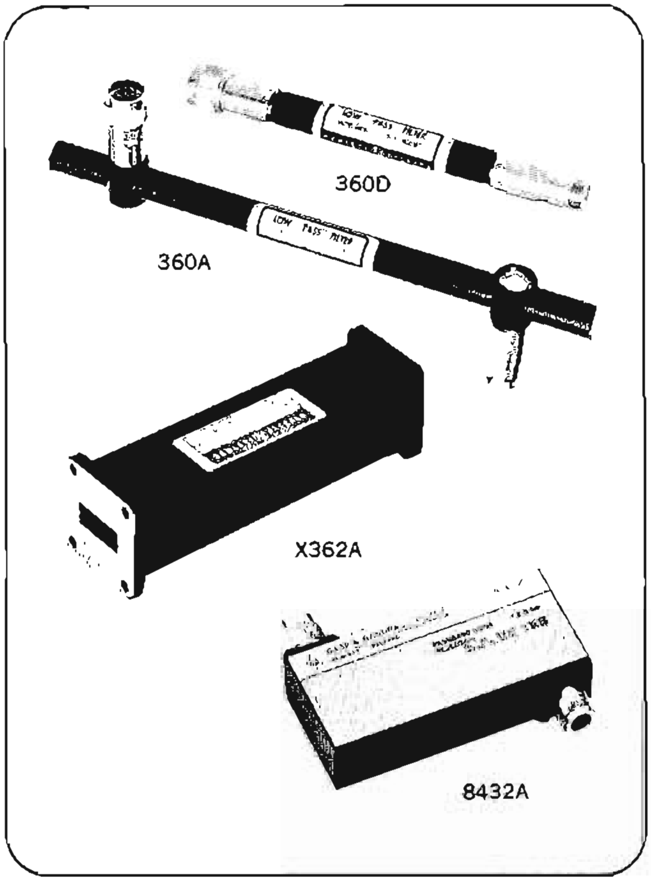
920A-B, X923A Specifications

Model	Frequency Range (GHz)	Waveguide Size EIA	Price
J920A	5.3–8.2	WR137	$200
H920A	7.05–10.0	WR112	165
X923A	8.2–12.4	WR90	150
P920B	12.4–18	WR62	190
K920B	18.0–26.5	WR42	325
R920B	26.5–40.0	WR28	350
X930A	8.2–12.4	WR90	300

LOW-PASS; BANDPASS FILTERS

Effective elimination of undesirable signals

Models 360A-D; 362A; 8430A-8436A



These Hewlett-Packard low-pass and bandpass filters facilitate microwave measurements by eliminating undesirable signals (such as harmonics) from the measurement system. Suppression of such signals is particularly important in applications such as slotted-line measurements, where harmonics generated by the signal source could otherwise impair measurement accuracy. These filters also can be used as preselectors for the HP 8555A Spectrum Analyzer. As such, they permit the maximum utilization of the analyzer's broad spectrum-width capability while ensuring virtually spurious-free displays.

Specifications, 360 Series

HP Model	360A	360B	360C	360D
Cut-off frequency	700 MHz	1200 MHz	2200 MHz	4100 MHz
Insertion loss	≤1 dB below 0.9 times cut-off frequency			
Rejection	≥50 dB at 1.25 times cut-off frequency			
Impedance	50 ohms through pass band; should be matched for optimum performance			
SWR	<1.6 to within 100 MHz of cut-off		<1.6 to within 200 MHz of cut-off	<1.6 to within 300 MHz of cut-off
Connectors	Type N, one male, one female			
Overall length (in.) (mm)	10⅞ 276	7-7/32 183	10-25/32 274	7⅜ 187
Center line (in.) to male end (mm)	2⅛ 54	2⅛ 54	—	—
Center line (in.) to female end (mm)	2¼ 57	2¼ 57	—	—
Shipping weight (lb) (kg)	2 0,9	2 0,9	2 0,9	1 0,45
Price	$115	$105	$95	$90

Specifications, 362A Series

HP Model	X362A	M362A	P362A	K362A*	R362A*
Passband (GHz)	8.2-12.4	10.0-15.5	12.4-18.0	18.0-26.5	26.5-40.0
Stop band (GHz)	16-37.5	19-47	23-54	31-80	47-120
Passband insertion loss	less than 1 dB	less than 1 dB	less than 1 dB	less than 1 dB	less than 2 dB
Stopband rejection	at least 40 dB	at least 40 dB	at least 40 dB	at least 40 dB	at least 35 dB
SWR	1.5	1.5	1.5	1.5	1.8
Waveguide size, in. (EIA)	1 x ½ (WR 90)	0.850 x 0.475 (WR 75)	0.702 x 0.391 (WR 62)	½ x ¼ (WR 42)	0.360 x 0.220 (WR 28)
Length, in. (mm)	5-11/32(136)	4-15/32(114)	3-11/16(94)	2½(64)	1-21/32(42)
Shipping weight, lb (kg)	2(0,9)	2(0,9)	13/16(0,37)	⅓(0,15)	¼(0.11)
Price	$450	$350	$375	$385	$420

*Circular flange adapters: K-band (UG425/U), HP 11515A, $60 each; R-band (UG-381/U), HP 11516A, $50 each.

Specifications, 8430 Series

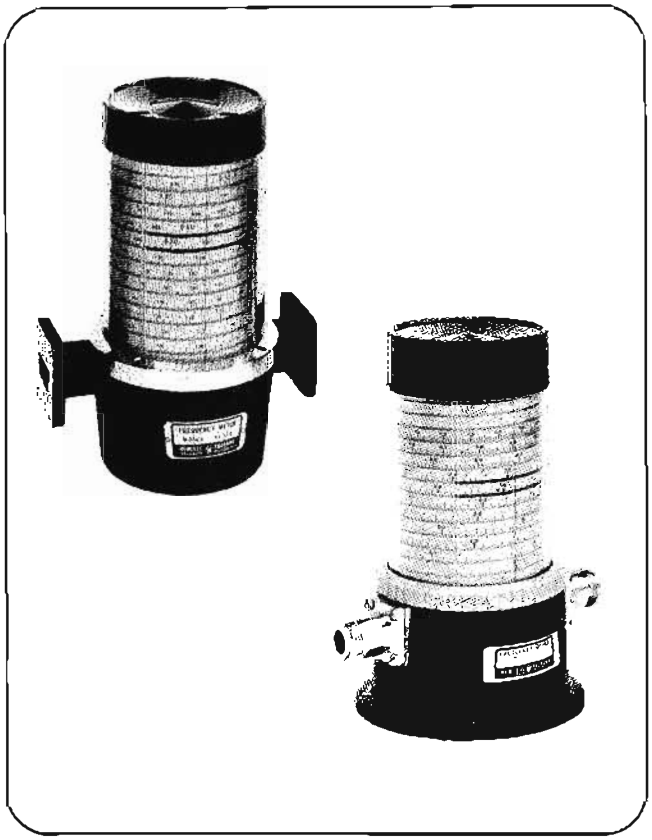
HP Model	Passband frequency (GHz)	Max. passband insertion loss	Rejection band attenuation: Below passband Frequency (GHz)	Below passband Attenuation	Above passband Frequency (GHz)	Above passband Attenuation	Dimensions (in.)	Dimensions (mm)	Shipping weight (lb)	Shipping weight (kg)	Price
8430A	1 to 2	2 dB	≤0.8	≥50 dB	2.2 to 20	≥45 dB	5½ x 4¾ x 1	140 x 121 x 25	3	1,4	$335
8431A	2 to 4	2 dB	≤1.6	≥50 dB	4.4 to 20	≥45 dB	5½ x 3 x 1	140 x 76 x 25	3	1,4	$335
8432A	4 to 6	2 dB	≤3.5	≥50 dB	6.5 to 20	≥45 dB	4½ x 2 x 1	114 x 51 x 25	2	0,9	$335
8433A	6 to 8	2 dB	≤5.5	≥50 dB	8.5 to 20	≥45 dB	4 x 1½ x 1	102 x 38 x 25	2	0,9	$335
8434A	8 to 10	2 dB	≤7.5	≥50 dB	10.5 to 17	≥45 dB	4⅝ x 1 x 1	118 x 25 x 25	2	0,9	$335
8435A	4 to 8	2 dB	≤3.2	≥50 dB	8.8 to 20	≥45 dB	3⅝ x 1¾ x 1	92 x 45 x 25	2	0,9	$335
8436A	8 to 12.4	2 dB	≤6.9	≥50 dB	13.5 to 17	≥45 dB	2⅞ x 1 x 1	73 x 25 x 25	1	0,45	$335

Connectors: Type N, one male, one female.

FREQUENCY METERS

For general-purpose or lab use

Models 532A/B, 536A, 537A



Advantages

- High resolution, easy-to-read dial
- Direct reading
- Broadband
- Accuracy specified over 20°C and 0 to 100% relative humidity

These direct-reading frequency meters allow you to measure frequencies from 5.30 to 40 GHz in waveguide and from 960 MHz to 12.4 GHz in coax quickly and accurately. Their long scale length and numerous calibration marks provide a high resolution which is particularly useful when measuring frequency differences or small frequency changes. Frequency is read directly in GHz so no interpolation or charts are required.

The instruments comprise a special transmission section with a high-Q resonant cavity which is tuned by a choke plunger. A 1-dB or greater dip in output indicates resonance; virtually full power is transmitted off resonance. Tuning is by a precision lead screw, spring-loaded to eliminate backlash. Resolution is enhanced by a long, spiral scale calibrated in small frequency increments. For example, Model X532B has an effective scale length of 77 inches (1956 mm) and is calibrated in 5-MHz increments. Resettability is extremely good, and all frequency calibrations are visible so you can tell at a glance the specific portion of the band you are measuring. Except for the J532A, there are no spurious modes or resonances. (See note 4 below.)

Specifications, 532A Series, 536A and 537A

Model	Frequency Range (GHz)	Dial Accuracy (%)	Overall Accuracy[1] (%)	Dip at Resonance	Calibration Increment (MHz)	Fits Waveguide		Equivalent Flange	Size in. (mm)			Weight lb (kg)		Price
						Nom. OD(in)	EIA		Length	Height	Depth	Net	Shipping	
536A	0.96–4.20	0.10[2]	0.17[3]	Note 6	2				6 (152)	9⅛ (232)	6 (152)	10 (4,5)	13 (5,9)	$600
537A	3.7–12.4	0.10	0.17	1 dB min	10				4⅝ (118)	5¾ (146)	3½ (89)	4 (1,8)	5 (2,3)	$525
J532A	5.30–8.20[4]	0.033	0.065	1 dB min	2	1½ x ¾	WR137	UG-441/U	6¼ (159)	9⅛ (232)	4½ (114)	8 (3,6)	11 (5,0)	$550
H532A	7.05–10.0	0.040	0.075	1 dB min	2	1¼ x ⅝	WR112	UG-138/U	6¼ (159)	8 (203)	4⅜ (111)	6 (2,7)	9 (4,1)	$650
X532B	8.20–12.4	0.050	0.08	1 dB min	5	1 x ½	WR90	UG-39/U	4½ (114)	6⅛ (156)	2⅞ (73)	3 (1,4)	4 (1,8)	$325
P532A	12.4–18.0	0.068	0.10	1 dB min	5	0.702 x 0.391	WR62	UG-419/U	4½ (114)	6¼ (159)	2¾ (70)	3 (1,4)	4 (1,8)	$350
K532A[5]	18.0–26.5	0.077	0.11	1 dB min	10	½ x ¼	WR42	UG-595/U	4½ (114)	5⅜ (137)	2⅞ (73)	2 (0,9)	3 (1,4)	$525
R532A[5]	26.5–40.0	0.083	0.12	1 dB min	10	0.360 x 0.220	WR28	UG-599/U	4½ (114)	5½ (140)	2¾ (70)	2 (0,9)	3 (1,4)	$525

[1] Includes allowance for 0 to 100% relative humidity, temperature variation from 13 to 33°C, and backlash.

[2] 0.15, 0.96 to 1 GHz.

[3] 0.22, 0.96 to 1 GHz.

[4] Because of the wide frequency range of the J532A, frequencies from 7.6 to 8.2 GHz can excite the TE_{112} mode when the dial is set between 5.3 and 5.6 GHz.

[5] *Circular flange adapters:* K-band (UG-425/U) 11515A, $60 each; R-band (UG-381/U) 11516A, $50 each.

[6] 1 dB min., 1-4 GHz; 0.6 dB min., 0.96-1 GHz and 4-4.2 GHz.

TUNERS, PHASE SHIFTERS

Precision instruments for lab or general use

Models 870A, 885A

885A Waveguide Phase Shifters

HP 885A Phase Shifters provide accurate, controllable phase variation in the J-, X-, and P-band frequency ranges. They are particularly useful in microwave bridge circuits where phase and amplitude must be adjusted independently. They also are used in the study of phased arrays.

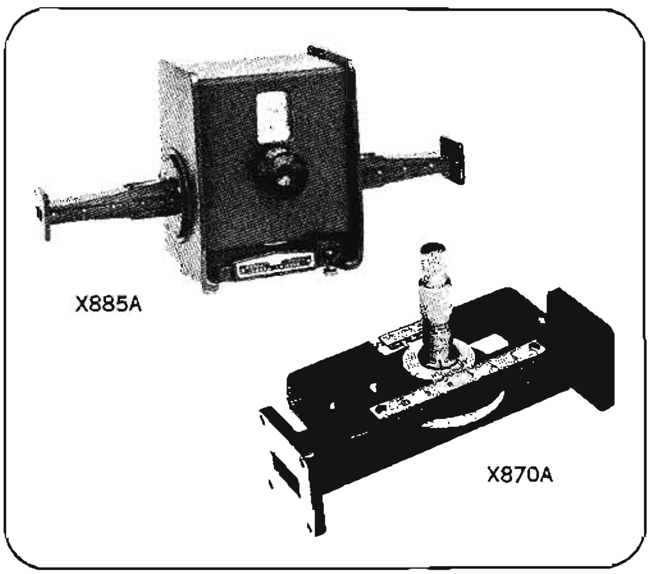
The instruments are differential phase devices; that is, they add or subtract a known phase shift from the total phase shift which a wave undergoes in traveling through the device.

The instruments have high accuracy over their entire phase range, —360 to +360 electrical degrees, have low power absorption, are simple to operate, and require no charts or interpolation. They are sturdily built, comprising two rectangular-to-circular waveguide transitions with a dial-driven circular waveguide mid-section. These waveguide phase shifters are housed in cast aluminum containers for extreme rigidity and durability.

Specifications, 885A

Model	Frequency Range (GHz)	Differential Phase Angle Range[1]	Accuracy[2] (The smaller of)	Insertion Loss[3]	SWR (max.)	Power Rating (Watts)	Waveguide Size (EIA)	Waveguide Flange	Weight Net lb	Weight Net kg	Weight Shipping lb	Weight Shipping kg	Price
J885A	5.3-8.2	$-360°$ to $+360°$	$\pm 3°$ or $0.1\ \Delta\phi$	<2 dB	1.35	10	WR137	UG-344/U	14	6,3	18	8,2	$950
X885A	8.2-12.4	$-360°$ to $+360°$	$\pm 2°$ ($\pm 3°$, 10-12.4 GHz) or $0.1\Delta\phi$	<1 dB, 8.2-10 GHz; <2 dB, 10-12.4 GHz	1.35	10	WR90	UG-39/U	8	3,6	11	5,0	$725
P885A	12.4-18	$-360°$ to $+360°$	$\pm 4°$ or $0.1\ \Delta\phi$	<3 dB	1.35	5	WR62	UG-419/U	6	2,7	8	3,6	$900

[1] Can be shifted continuously through any number of cycles.
[2] $\Delta\varnothing$ = phase difference in degrees.
[3] Variation with frequency (fixed phase setting): approx. 1 dB.
Variation with phase setting (fixed frequency): <0.4 dB, J885A; 0.3 dB max. 8.2 to 10 GHz and 0.4 dB max. 10 to 12.4 GHz, X885A; <0.5 dB, P885A.



870A Slide-Screw Tuners

Waveguide slide-screw tuners are used primarily for correcting discontinuities or for "flattening" waveguide systems. They are also used to match loads, terminations, bolometer mounts, or antennas to the characteristic admittance of the waveguide. They are particularly valuable in determining experimentally the position and magnitude of matching structures required in waveguide systems.

HP 870A tuners consist of a waveguide slotted section with a precision-built carriage on which is mounted an adjustable probe. The position and penetration of the probe is adjusted to set up a reflection which is used to cancel out an existing reflection in a system.

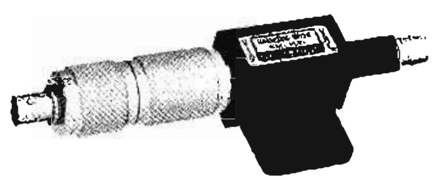
Probe penetration into the guide is varied by a micrometer drive. Position of the probe along the guide is adjusted by a thumb-operated wheel, and position can be read to 0.1 mm on a vernier scale. An SWR of 20 can be corrected to 1.02, and small SWR's can be corrected exactly.

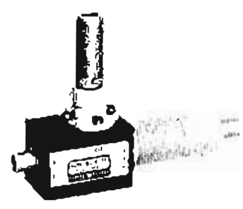
Specifications, 870A

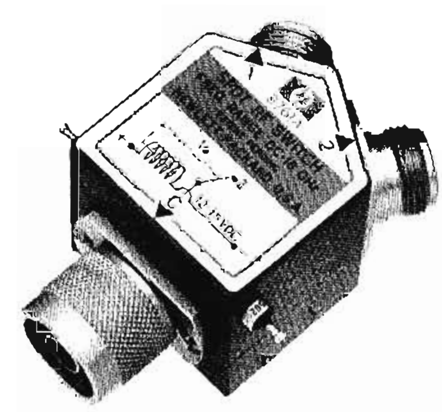
Model	Freq. Range (GHz)	Fits Waveguide Size Nom. OD (in.)	Fits Waveguide Size (EIA)	Equivalent Flange Type	Length (in.)	Length (mm)	Net Weight (lbs.)	Net Weight (kg)	Shipping Weight (lbs.)	Shipping Weight (kg)	Price
P870A	12.40-18.00	0.702 x 0.391	WR62	UG-419/U	5	127	½	0,23	2	0,9	$275
X870A	8.20-12.40	1 x ½	WR90	UG-39/U	5½	140	¾	0,34	2	0,9	$250

Correctable SWR on all models: 20.
Insertion loss dB at corrected SWR of 20: 2 dB max.

MIXERS, COAXIAL SWITCHES
Broadband mixers and switches
Models 934A, P932A, 8761A/B


P932A


934A


8761A Option 001

934A, P932A Harmonic Mixers

HP 934A, P932A simplify frequency measurements from 2 to 18 GHz. They are also excellent as RF mixers in phase-stabilized signal sources. Both feature high sensitivity, yet require no tuning.

Specifications 934A, P932A					
Model	Frequency Range (GHz)	Maximum Input	Typical Sensitivity	Min. video output*	Price
934A	2 to 12.4	100 mW	−48 dBm at 3.5 GHz −25 dBm at 10 GHz	1.4 mV p-p	$150
P932A	12.4 to 18	100 mW	−10 dBm	0.4 mV p-p	$350

*With 0 dBm input signal.

8761A/B Coaxial Switch

The HP 8761 is a single-pole, double-throw coaxial switch with low standing-wave ratio, low insertion loss, and good isolation from dc to 18 GHz. Mechanically, the switch is a break-before-make type controlled by a latching solenoid. Solenoids are available in 12- and 26-volt ratings and can be operated by dc or pulsed signals. Any of seven coaxial connectors, or a 50-ohm termination, may be specified for each port.

Specifications, 8761A/B

Characteristic impedance: 50 ohms.
Frequency range: dc to 18 GHz.
Standing-wave ratio: looking into one of the connected ports with 50 ohms (or built-in termination) on the other, third port open.

Frequency	Connector type		
	7-mm	N	3-mm (SMA)
dc-12.4 GHz dc-18 GHz	<1.15 (1.20) <1.20 (1.25)	<1.20 (1.25) <1.25 (1.30)	<1.25 (1.30) <1.30 (1.35)
SWR in parenthesis applies to switch with built-in termination.			

These specifications apply when connected ports are of the same connector type; for mixed connector types, the larger of the two VSWR's applies. N-connector VSWR specifications apply to Option 4 connectors.

Insertion loss: <0.5 dB, dc-12.4 GHz; <0.8 dB, dc-18 GHz.
Isolation: >50 dB, dc-12.4 GHz; >45 dB, dc-18 GHz.
Power: safely handles 10 W average, 5 kW peak, without built-in termination; built-in termination rated at 2 W average, 100 W peak.
Switching energy: 1.5 W for 20 ms (permanent magnet latching).
Solenoid voltages (dc or pulsed): 12-15 V, 8761A; 24-30 V, 8761B.
Switching speed: 35-50 ms (includes settling time).
Life: >1,000,000 switchings.
Dimensons: 1.6 x 1.5 x 1.5 in. (41 x 38 x 38 mm), excluding connectors and solenoid terminals.
Weight: net, 5-8 oz (140-220 gm); shipping, 8-11 oz (220-300 gm).
Price: Model 8761, $150 each, 1-9; $140 each, 10-24. Add $35 for built-in termination.

Ordering information, 8761A/B

Specify solenoid voltage and connectors (including built-in 50Ω termination) by the alphabetic suffix on the switch model number and the appropriate three-digit option number.

Port 1 Port 2 Port C

8761A Option 001

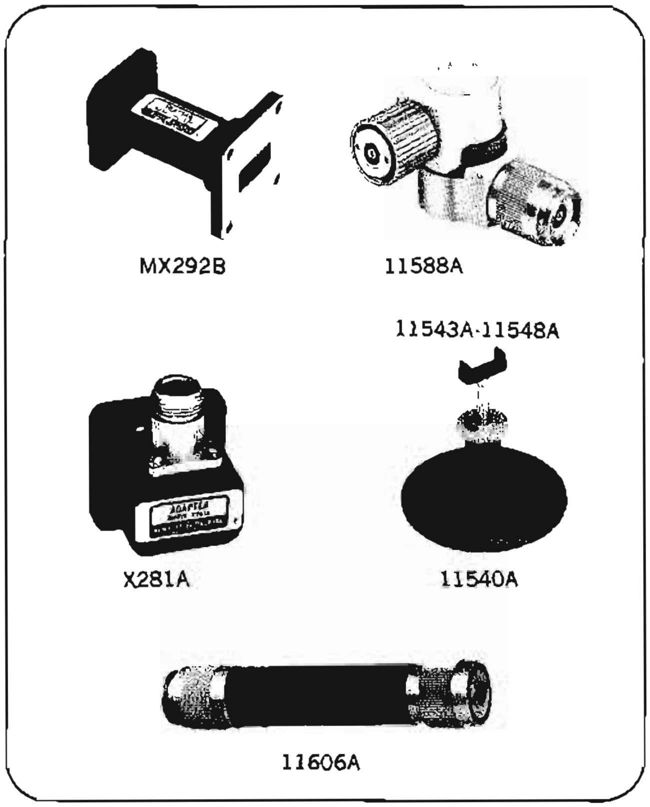
Solenoid Voltage Connector Configuration

A: 12 - 15 V; B: 24 - 30 V

Option Code	Connector Type	Option Code	Connector Type
0	N Jack	4	7-mm for UT-250 Coax
1	N Plug	5	3-mm Jack
2	7-mm Jack	6	3-mm Plug
3	7-mm Plug	7	50Ω Termination

"Jack" identifies the connector with fixed threads; "plug" identifies the connector with the coupling nut.

MISCELLANEOUS EQUIPMENT
Increase flexibility of microwave measurements
Models 281A-B, 292A-B, 11524A/25A, 11588A, 11606A



281A-B Coax to Waveguide Adapters

HP 281A-B adapters transform waveguide impedance into 50-ohm coaxial impedance. Power can be transmitted in either direction, and each adapter covers the full frequency range of its waveguide band with SWR less than 1.25.

Specifications 281A,B

HP Model	SWR	Frequency Range (GHz)	Waveguide Size EIA	Coaxial Connector	Length (in.)	Length (mm)	Qty 1-4 Price
S281A	1.25	2.60-3.95	WR284	N Female	2½	64	$75
G281A	1.25	3.95-5.85	WR187	N Female	2⅛	54	$60
J281A	1.25*	5.30-8.20	WR137	N Female	2	51	$55
H281A	1.25	7.05-10.0	WR112	N Female	1⅝	41	$50
X281A	1.25	8.20-12.4	WR90	N Female	1⅜	35	$45
X281B	1.25	8.20-12.4	WR90	APC-7**	1⅜	35	$90
P281B	1.25	12.4-18	WR62	APC-7**	15/16	24	$95

*1.3 from 5.3 to 5.5 GHz.
**Option 013. Furnished with stainless steel N-female connector, less $15.

Waveguide to Waveguide Adapters

Models 292A-B waveguide-to-waveguide adapters connect two different waveguide sizes with overlapping frequency ranges. The 292A consists of a short tapered section of waveguide. The 292B is broached waveguide with a step transistion between waveguide sizes.

Specifications 292A,B

HP Model	SWR	Length (in.)	Length (mm)	Frequency range (GHz)	Price
HX292B	1.05	1½	38	8.20 to 10.0	$60
MX292B	1.05	2⅜	60	10.0 to 12.4	$70
MP292B	1.05	2⅜	60	12.4 to 15.0	$80
NP292A	1.05	2⅜	60	15.0 to 18.0	$60
NK292A	1.05	2⅜	60	18.0 to 22.0	$60

11524A, 11525A, 11533A, 11534A Coax to Coax Adapters

These coaxial adapters, not pictured here, permit easy interconnection of 50-ohm precision 7-mm (APC-7) connectors and 50-ohm Type N or SMA (3-mm type) connectors.

HP Model	Description	Shipping Weight	Price
11524A	APC-7 to N female	4 oz (110 gm)	$70
11525A	APC-7 to N male	5 oz (140 gm)	$70
11533A	APC-7 to SMA male	5 oz (140 gm)	$115
11534A	APC-7 to SMA female	5 oz (140 gm)	$115

11588A Swivel Adapter, 11606A Rotary Air Line

The 11606A rotary air line and the 11588A swivel adapter are capable of a full 360° of rotation. A combination of the air line and the adapter permits rigid coax movement in three dimensions. Even the most awkwardly shaped devices can be easily connected or disconnected in a coax system with the aid of these components.

Specifications, 11588A and 11606A

Frequency range: dc to 12.4 GHz.
Reflection coefficient (SWR): 0.048 (1.1). Ambiguity due to rotation 0.003 (—50 dB).
Insertion loss: 0.5 dB.
Connectors: 11588A, one precision 7-mm jack and one APC-7; 11606A, one 7-mm plug and one 7-mm jack. Combinations of APC-7, Type N, and 3-mm type SMA available; prices on request.
Dimensions: 11588A, 1 5/8" x 2 5/16" x 1 3/16" (42 x 59 x 30 mm); 11606A, 3 15/16" x 3/4" x 3/4" (100 x 19 x 19 mm).
Weights: 11588A, net, 8 oz (220 gm), shipping, 11 oz (310 gm); 11606A, net, 6 oz (170 gm), shipping, 11 oz 310 gm).
Prices: Model 11588A, $200; Model 11606A, $150.

Waveguide Stand, Waveguide Clamps

The 11540A waveguide stand locks HP waveguide clamp at any height from 2¾" to 5¼" (70 to 133 mm). The stand is 2½" (64 mm) high, and the base measures 4¾" (121 mm) in diameter. Price: 11540A, $10. The waveguide clamps are offered in six sizes to hold waveguide covering frequencies from 5.30 to 40 GHz. They consist of a molded plastic cradle with a center rod. Price: 11543A-11548A, $5 each.

SWR METER

Reduced noise for greater usable range

Model 415E

The Hewlett-Packard Model 415E SWR Meter is a low-noise tuned amplifier-voltmeter calibrated in dB and SWR for use with square-law detectors. It is an extremely useful and versatile instrument, measuring SWR, attenuation, gain, or any other parameter determined by the ratio of two signal levels. The standard tuned frequency is 1000 Hz and is adjustable over a range of about 7% for exact matching to the source modulation frequency. Amplifier bandwidth is also adjustable, from 15 to 130 Hz. The narrow bandwidth facilitates single-frequency measurements by reducing noise, while the widest setting accommodates a sweep rate fast enough for oscilloscope presentation.

The 415E has a very low noise figure, less than 4 dB. This represents a 6 to 10 dB improvement over other SWR meters. Equally significant is the fact that the noise figure has been optimized for source impedances presented by detectors most often used with SWR meters. As a result the 415E has greater measurement range because the reduction in noise permits the measurement of lower-level signals for a given signal-to-noise ratio.

A precision 60-dB attenuator with an accuracy of 0.05 dB/10 dB assures high accuracy in attenuation measurements. In addition, an expand-offset feature allows any 2-dB range to be expanded to full scale for maximum resolution. Linearity on the expanded ranges is ± 0.02 dB, permitting full utilization of the increased resolution; high accuracy is possible on the normal scales as well, for linearity is limited only by meter resolution. The meter itself has individually calibrated, mirror-backed scales plus a rugged taut-band movement for full realization of the inherently high accuracy, resolution, and linearity of the instrument.

The Model 415E operates with either crystal or bolometer detectors. Both high- and low- impedance inputs are available for crystal detectors (see page 389), optimum crystal source impedances being 50 to 200 and 2500 to 10,000 ohms respectively. For operation with bolometers, the 415E provides precise bias currents of 4.5 and 8.7 mA into 200 ohms, as selected at the front panel. This bias is peak-limited for positive bolometer protection.

Both ac and dc outputs are provided for use of the 415E as a high-gain tuned amplifier and with recorders. The solid-state 415E can be operated with an internally mounted battery pack (optional extra) for completely portable use or to eliminate ground loops.

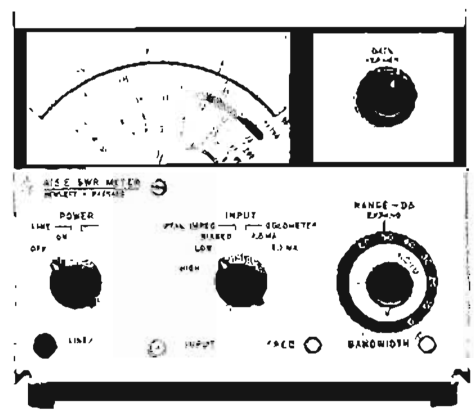
Specifications

Sensitivity: 0.15 μV rms for full-scale deflection at maximum bandwidth (1 μV rms on high impedance crystal input).

Noise: at least 7.5 dB below full scale at rated sensitivity and 130 Hz bandwidth with input terminated in 100 or 5000 Ω; noise figure less than 4 dB.

Range: 70 dB in 10- and 2-dB steps.

Accuracy: ± 0.05 dB/10-dB step; maximum cumulative error between any two 10-dB steps, ± 0.10 dB; maximum cumulative error between any two 2-dB steps, ± 0.05 dB; linearity, ± 0.02 dB on expand scales, determined by inherent meter resolution on normal scales.



415E

Input: unbiased low and high impedance crystal (50-200 and 2500-10,000 Ω optimum source impedance respectively for low noise); biased crystal (1 V into 1 kΩ); low and high current bolometer (4.5 and 8.7 mA $\pm 3\%$ into 200 Ω), positive bolometer protection; input connector, BNC female.

Input frequency: 1000 Hz adjustable 7%; other frequencies between 400 and 2500 Hz available on special order.

Bandwidth: variable, 15-130 Hz; typically less than 0.5 dB change in gain from minimum to maximum bandwidth.

Recorder output: 0-1 V dc into an open circuit from 1000 Ω source impedance for ungrounded recorders; output connector, BNC female.

Amplifier output: 0-0.3 V rms (Norm), 0-0.8 V rms (Expand) into at least 10,000 Ω for ungrounded equipment; output connector, dual banana jacks.

Meter scales: calibrated for square-law detectors; SWR: 1-4, 3.2-10 (Norm); 1-1.25 (Expand). dB: 0-10 (Norm); 0-2.0 (Expand); battery: charge state.

Meter movement: taut-band suspension, individually calibrated mirror-backed scales; expanded dB and SWR scales greater than $4\frac{1}{4}$ in. (108 mm) long.

RFI: conducted and radiated leakage limits are below those specified in MIL-I-6181D.

Power: 115-230 V $\pm 10\%$, 50-400 Hz, 1 W; optional rechargeable battery provides up to 36 hr continuous operation.

Dimensions: $7\frac{25}{32}$ in. wide, $6\frac{3}{32}$ in. high, 11 in. deep from panel (190 x 155 x 279 mm).

Weight: net, 9 lb (4 kg); shipping, 13 lb (5,8 kg).

Accessory available: 11057A Handle, fits across top of instrument for carrying convenience.

Combining cases: 1051A, $11\frac{1}{4}$ in. (286 mm) deep. 1052A, $16\frac{3}{8}$ in. (416 mm) deep.

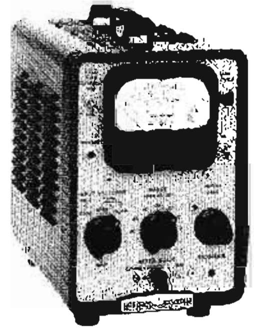
Price: HP Model 415E, $425.

Options: 001. rechargeable battery installed, add $100; 002. rear-panel input connector in parallel with front-panel connector, add $25.

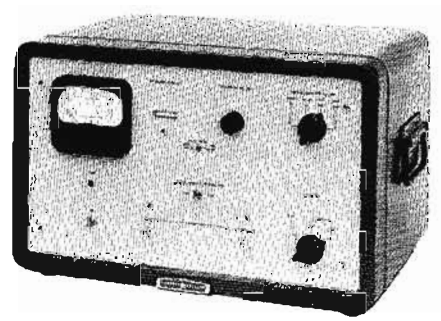
SWR AND RATIO METERS

For convenient SWR measurements

Models 415B, 416B



415B



416B

415B Standing Wave Indicator

Similar to the 415E, this meter is a tuned voltmeter for SWR measurements with Hewlett-Packard slotted lines and detector mounts. It has an input selector for both bolometers and crystals. A special 5 dB attenuator is incorporated to increase resolution through use of the upper portion of the logarithmic meter scale.

Specifications, 415B

Input: "bolo" (200 ohms), bias provided for 8.7 or 4.3 mA bolometer or 1/100 amp fuse; "Crystal" (200 ohms) for crystal rectifier; "Crystal" (200 kΩ) high impedance for crystal rectifier as null detector; BNC connector.

Sensitivity: 0.1 μV at 200 ohms for full-scale deflection.

Noise: at least 5 dB below full scale when operated from 200-ohm resistor at room temperature.

Frequency: 1000 Hz ±2%; other frequencies, 315 to 2020 Hz, available on special order; should not be harmonically related to power line frequency.

Bandwidth: 30 Hz (nominal).

Range: 70 dB; input attenuator provides 60 dB in 10-dB steps; accuracy, ±0.1 dB per 10-dB steps.

Calibration: square law; meter reads SWR, dB.

Scale selector: "Normal," "Expand" and "−5 dB."

Power: 115 or 230 volts ±10%, 50 to 60 Hz, 55 watts.

Dimensions: cabinet: 7½" wide, 11¾" high, 12½" deep (191 x 299 x 318 mm).

Weight: net, 14 lbs (6,3 kg); shipping, 15 lbs (6,8 kg) (cabinet); net, 17 lbs (7,7); shipping, 27 lbs (12,2) (rack mount).

Price: HP 415B, $540 (cabinet); HP 415BR, $550 (rack mount).

416B

The HP 416B is designed for use with unleveled signal sources in the measurement of reflection coefficient. The ratio meter provides valid results independent of incident power variations as high as 20:1. Either swept- or fixed-frequency measurements can be made using the Model 416B. A high-impedance output on the rear of the instrument permits swept-frequency measurements to be presented on an oscilloscope or preserved on a graphic recorder. The 416B operates with either crystals or bolometers.

Specifications, 416B

Meter presentation

Reflection coefficient (%): four ranges, 100%, 30%, 10% and 3% reflection.

SWR: two ranges, 1.06 to 1.22 and 1.2 to 1.9.

DB: 0 to −10 dB; spans 0 to −40 dB in four 10-dB steps.

Accuracy: crystal, ±3% of full scale; bolometer, same as crystal except ±5% for incident input voltage below 1 mV.

Calibration: for use with square law detectors.

Frequency: 1000 Hz input voltage.

Input voltage (for full-scale deflection):

	Crystal	Bolometer
Incident channel	3 to 100 mV rms	0.3 to 10 mV rms
Reflected channel	3 μv to 100 mV rms	0.3 μv to 10 mV rms

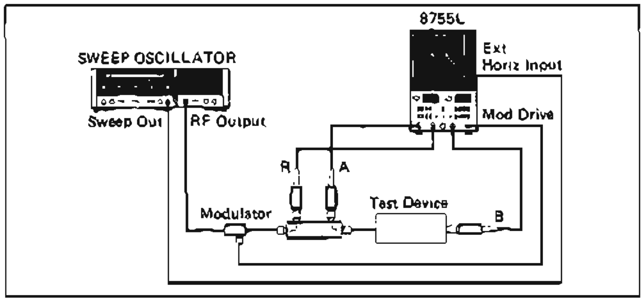
FREQUENCY RESPONSE TEST SETS
Pushbutton measurements, 0.1 to 18 GHz
Model 8755L/8755M

Description

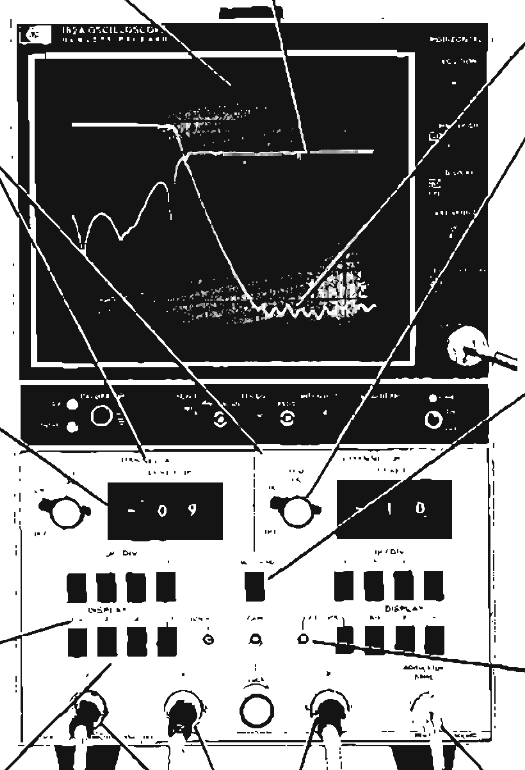
Model 8755 series Frequency Response Test Sets are precision detection and display systems for making the basic microwave measurements of insertion gain/loss and return loss (VSWR) from 100 MHz to 18 GHz.

The Test Set system is both easy to understand and simple to operate. It is an extremely versatile measurement system and the 8755 is economical, thus enhancing its high value.

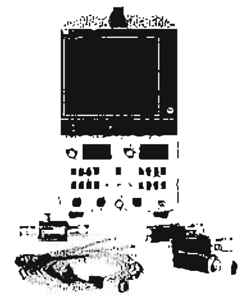
Simultaneous Insertion and Return Loss



Features

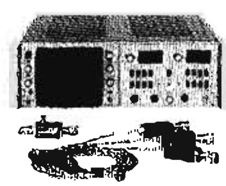


Systems



8755L

Consists of:
- 8755A Swept Amplitude Analyzer
- 182A Option 807 Display
- 11664A Detectors (3 each)
- 11665A Modulator



Model 8755M

Consists of:
- 8755A Swept Amplitude Analyzer
- 180D Option 807 Display
- 11664A Detectors (3 each)
- 11665A Modulator

System Specifications

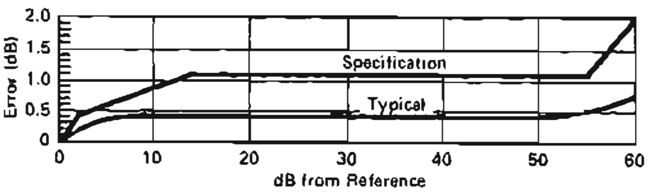
Function: Models 8755L and 8755M are configured test sets for making swept frequency response measurements of return loss, insertion loss, and power. The test sets do not include a sweep oscillator or directional couplers.

Frequency range: 100 MHz to 18 GHz.

Measurement range:

Single channel: +10 dBm to −50 dBm (noise level).
Ratio of two channels: 60 dB.

Ratio Measurement Accuracy:



Accuracy curve shows overall system uncertainty for a single detector measurement using the OFFSET dB controls; it is also the accuracy of a ratio measurement when the power level to one detector does not change level.

Resolution: Independent for each channel in steps of 10, 5, 1, or 0.25 dB per division.

8755L: 1 Div. ~ 1.29 cm. **8755M:** 1 Div. ~ 1 cm.

Detector return loss: .1-4 GHz, >20 dB; 4-8 GHz, >16 dB; 8-16 GHz, >10 dB; 16-18 GHz, >7 dB.

Temperature Range: Operation, 0 to 55°C; storage, −40°C to 75°C.

Power: 48 to 440 Hz, 115/230 V ±10%, typ. 85 watts.

Weight:

8755L: Net, 34.3 lb (15,5 kg). Shipping, 52 lb (23 kg).

8755M: Net, 31.8 lb (14,5 kg). Shipping, 50 lb (22 kg).

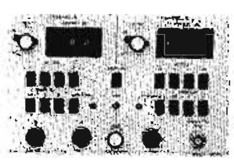
Dimensions:

8755L (182A Display): 7-15/16 in. wide x 13-5/16 in. high x 19⅝ in. deep overall (201,6 x 338,1 x 498,5 mm).

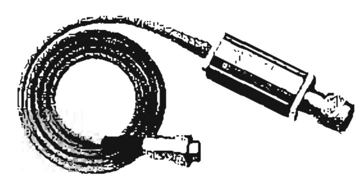
8755M (180D Display): 16¾ in. wide x 5-7/32 in. high x 21⅜ in. deep overall (425 x 132,6 x 543 mm).

Price: 8755L: $3,200.00.
8755M: $3,300.00.

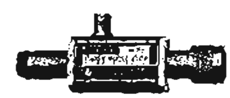
Individual Instrument Specifications



8755A



11664A



11665A

8755A

Function: Swept Amplitude Analyzer plug-in for 180 series oscilloscopes. Has three inputs (R, A, B) which process the 11664A Detectors' outputs.

Weight: Net, 6 lb, 4 oz (2,8 kg).

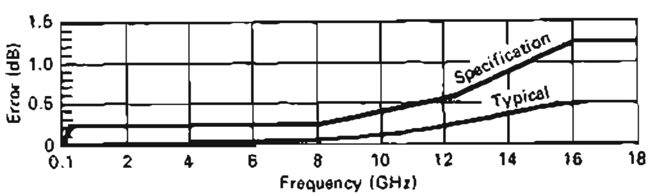
Shipping, 10 lb (4,5 kg).

Price: $1,350.00.

11664A

Function: Detector designed for the 8755A.
Detects the envelope of the modulated microwave signal. Uses hot carrier diode for detection.

Frequency Response:



Impedance: 50 ohms nominal.

Maximum Input Power: Damage level is +20 dBm (100 mW) power; 10 V dc.

Connector: Type N-Plug.

Dimensions: Cable length is 48 inches.

Weight: Net, 6 oz (0,17 kg). Shipping, 2 lb (0,9 kg).

Price: 11664A: $200.00.

Options:

001: APC-7 connector, add $25.00.
002: SMA-Jack connector. No Charge.

Accessories:

11679A: 25-foot Extension Cable, $50.00.
11679B: 200-foot Extension Cable, $190.00.

11665A

Function: Non-reflective on-off modulator designed for and powered by the 8755A.

Frequency Range:	Return Loss: On and Off	Insertion Loss: On	Insertion Loss: Off
0.1-0.2 GHz	≤1.92 SWR (≥10 dB)	≤3.8 dB	≥35 dB
0.2-4 GHz	≤1.43 SWR (≥15 dB)	≤3.8 dB	≥35 dB
4-8 GHz	≤1.67 SWR (≥12 dB)	≤3.8 dB	≥40 dB
8-12.4 GHz	≤2.32 SWR (≥8 dB)	≤4.3 dB	≥45 dB
12.4-18 GHz	≤2.32 SWR (≥8 dB)	≤5 dB	≥45 dB

Maximum Input: +24 dBm.

Drive Current: Nominally +50 mA in ON condition, −50 mA in OFF condition.

Connectors: Input N-Jack, Output N-Plug.

Weight: Net, 6 oz (0,17 kg). Shipping, 2 lb (0,9 kg).

Price: 11665A, $300.00.

Options:

011:	Input N-Jack, Output N-Jack.	No Charge
013:	Input N-Jack, Output APC-7	Add $25.00
021:	Input N-Plug, Output N-Jack	No Charge
022:	Input N-Plug, Output N-Plug	No Charge
023:	Input N-Plug, Output APC-7	Add $25.00

Display Units

Function: The display units are modified (Option 807) 180 series oscilloscope mainframes.

Price:

182A Option 807: Large Screen, cabinet style. $950.00.
180D Option 807: Std. Screen, rack style. $1,050.00.
181A Option 807: Storage, cabinet style. $1,950.00.
181AR Option 807: Storage, rack style. $2,025.00

COMPLETE CHARACTERIZATION OF LINEAR NETWORKS

Network analysis

A fundamental problem facing engineers is to predict the behavior of a network that is stimulated by an arbitrary signal and connected to other arbitrary networks. A way to solve this problem is to completely describe the network's behavior in the frequency domain. Network analysis accomplishes this for passive and active linear networks by measuring parameters at the network's ports. Network analysis creates thus a data model representing the actual network behavior as a function of frequency. (For description of the behavior of nonlinear devices see sections about Spectrum Analyzers and Wave Analyzers).

The engineer designing multicomponent networks tries to predict the performance of the final circuit from a knowledge of the parameters of individual components. The production engineer responsible for the manufacture of each component must know the tolerances allowable on the components to ensure a finished product within specifications. Network analysis helps these engineers to narrow the limits of uncertainty about network behavior.

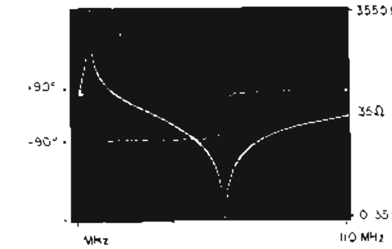
Network behavior

It is possible, to a certain extent, to predict circuit performance by calculation. However, theoretical calculations often disagree with actual measured values since a "perfect" network does not exist and since the electrical characteristics of a circuit may vary in a complicated way with frequency.

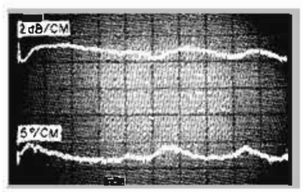
At frequencies above approximately 1 MHz, a single lumped element becomes a "circuit" consisting of the basic element plus a number of parasitics like stray capacitance, lead inductance and unaccountable absorptive losses. The magnitudes of these parasitics depend largely upon the construction of the device and are difficult or impossible to predict.

At frequencies above 1 GHz, the geometry of the components used in a circuit becomes comparable to the wavelength used. Lower frequency techniques and lumped-element theory are almost impossible to use for complete network characterization. To analyze the behavior of networks at microwave frequencies, distributed-element theory, that is transmission-line theory, has to be applied.

A device or "black box" may behave like a resistor at very low frequencies, like an L-C circuit at RF frequencies, and like a transmission line at microwave frequencies. This circuit behavior is difficult and impractical to predict by calculations. Network analysis enables the engineer to accurately measure circuit behavior in a speedy and convenient way.



Magnitude and phase of the complex impedance of a resonant circuit are measured with the 8407A Network Analyzer using the 11655A Impedance Probe. The calculated parallel resonance is 5.2 MHz. The unexpected series resonance at 60 MHz caused by circuit parasitics can be important information for circuit design.



The insertion loss and "nonlinear" portion of the phase shift of a PIN modulator are traced on the 8412A Phase Magnitude Display. The electrical length of the PIN modulator has been compensated by the line stretcher of the "transducer" used for transmission measurements with the 8410A.

Low frequency network analysis

At frequencies below 10 megahertz networks are characterized by measuring amplitude and phase changes through the network and its input and output impedance, h, y, and z—parameters as well as lumped component models are very common analytic tools at low frequency. Group delay, the derivative of phase, is also a significant measurement in many communications systems. All of these parameters can be measured using Hewlett-Packard's broad range of instrumentation.

Amplitude is measured either as a ratio of two signal levels or as an absolute level of one signal. Ratio measurements are typically displayed in dB so that the full dynamic range of the instrumentation can be utilized in observing both the high and low level response of a network. For a ratio measurement reading 0 dB the signal levels would have equal amplitudes. Similarly, ±20 dB would mean there is a 10 to 1 ratio between two signals. Absolute measurements are expressed in volts, dBV, or dBm. The term dBV is the logarithmic ratio between the unknown signal in volts and one volt. Likewise, dBm is the log ratio of power relative to 1 milliwatt.

Phase is a much more sensitive indicator of a circuit's behavior than amplitude. It thus provides valuable information for precisely determining the location of poles on a phase and log amplitude vs. log frequency plot (Bode Plot). In a similar fashion phase information would establish the frequency of resonance (Θ = zero degrees) with much greater resolution than amplitude information alone. Phase measurements also are used in circuit design for determining phase margins.

One source of distortion of a complex waveform occurs from the nonlinear phase shift of the waveform's frequency components as it passes through a network. The phase shifting characteristics of a network or system is called delay distortion or group delay and is defined as

$$T_g = \frac{d\Theta}{d\omega}$$

There are numerous techniques used for measure group delay. They include the phase slope, amplitude modulation, frequency modulation and frequency deviation techniques. Most Hewlett-Packard network analyzers can be used to make group delay measurements with at least one of these techniques.

Broadband detection techniques

Instruments using this technique accept the full frequency spectrum of the input signal. Eliminating the IF section of the frequency selective analyzer reduces the instrumentation cost while sacrificing noise and harmonic rejection. However, careful measurement techniques, using filters, can eliminate harmonic signals that would otherwise produce inaccurate measurements. Also noise is not a limitation in many applications.

The broadband technique is essential in network measurements where the input and output signal are not at the same frequency. For example, this is the type of instrumentation that would be used to measure the insertion loss of a mixer or frequency doubler.

In general a broadband measurement system is always source independent compared to some selective analyzers which use a companion tracking source. Source independence gives the user flexibility to choose a source with frequency accuracy, power output, and cost demanded by his application.

Frequency selective measurements

Frequency selective network analyzers are built as tracking receivers which convert swept RF signals to a constant IF signal. The lower frequency network analyzers (below 110 MHz) will generate a constant IF signal only when used with specific signal sources. These signal sources must supply two RF signals; one as a stimulas to the device under test and a second signal, offset in frequency, for tuning the input frequency of the analyzer. A more sensitive, low noise detection of the IF becomes possible. This provides increased accuracy and dynamic range for frequency selection measurements as compared to broadband instrumentation. Furthermore, precision IF attenuators allow high resolution, accurate IF substitution measurements.

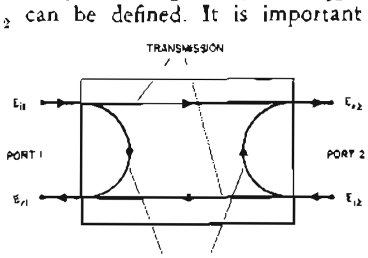
High frequency network analysis

At lower frequencies, currents and voltages can readily be measured. Current and voltage transfer functions and impedance, the ratio of voltage to current, are widely used circuit parameters. In circuit design, h, y or z parameters are used. At microwave frequencies, however, these parameters cannot be accurately measured because it is extremely difficult to establish the required short and open circuit measurement conditions. Also, voltage and current vary along the transmission line causing measurements to become arbitrary. Consequently, microwave phenomena are more commonly expressed in terms of power which is invariant along a lossless transmission line.

Parameters which describe the energy flow within a network are the scattering parameters or S-parameters. They are used at microwave frequencies because they are much easier to measure and design with than other kinds of parameters at these frequencies.

S-parameters describe the ratios of reflected and transmitted signals within a network.

S_{11} is the reflection coefficient at port 1, E_{r1}/E_{i1}, if $E_{i2} = 0$ (port 2 is terminated in its characteristic impedance). S_{21} is the transmission coefficient E_{r2}/E_{i1}, if $E_{i2} = 0$. By reversing the ports, S_{22} and S_{12} can be defined. It is important to



note that the network is always terminated in its characteristic impedance thus avoiding oscillation by active devices and other unwanted parasitic effects caused by open or short circuit terminations during measurements.

S-parameters completely characterize transistors, solid state devices and other active and passive linear networks. They are useful in the design of amplifiers, transistor circuit, and in flow graph analysis of multicomponent circuits.

Hewlett-Packard has developed a set of tutorials for measurement of and design with S-parameters: Application Notes 95, 117-1, 117-2; videotapes "S-Parameter Design Techniques Part 1" #800586, "S-Parameter Design Techniques Part 2", #800600; calculator programs "Microwave Circuit Design PAC, Vol. 1"; seminars on design techniques with S-parameters are also being offered.

With the increased use of microwave frequencies in communication systems and other new applications, S-parameter measurements become more and more important and are more generally used in design work. The accuracy and ease of S-parameter measurements are also available at RF frequencies. Since S-parameters completely characterize linear networks, they can mathematically be converted into any desired parameter set such as h, y and z parameters or return loss, impedance and transfer functions.

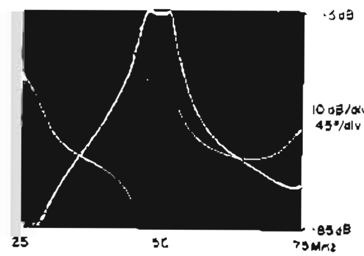
Hewlett-Packard helps the RF engineer with these parameter conversions, where desirable, by offering a variety of displays, display overlays, a reflectometer calculator and software for Hewlett-Packard programmable calculators.

Network analyzers

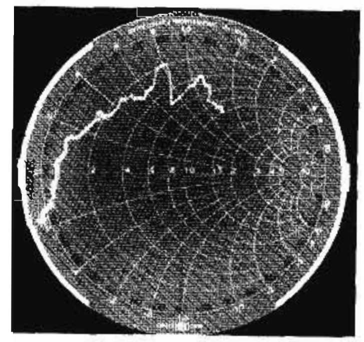
Hewlett-Packard offers a complete line of network analyzers throughout the frequency range 1 Hz to 40 GHz. Compared to other instrumentation that can be used for network characterization such as broadband voltmeters, log amplifiers, oscilloscopes, crystal detectors and slotted lines, network analyzers offer the following advantages.

Versatility of measurements

Hewlett-Packard network analyzers are capable of measuring or testing a large variety of parameters of inumerous networks—passive, active and networks with various characteristic impedances. A broad frequency coverage and the design of the network analyzers achieve this measurement versatility. As ratiometers, their performance is virtually independent of the power level used to stimulate the device under test. Their dual-channel capability enables measurement of various parameters through the use of "transducers"; besides S-parameters, the ratio of voltage to current (impedance) or voltage and current transfer functions can be measured. Comparison



The insertion loss and phase shift of a tunable 50 MHz bandpass filter are traced on the 8412A Phase-Magnitude Display used with the 8407A Network Analyzer. The swept frequency display allows rapid adjustments for linear phase shift through the passband. Group delay can be computed from the phase information displayed.



The reflection coefficient S_{11} of a transistor is measured over the frequency range 300 MHz to 700 MHz. The measurements setup includes the 8410A Network Analyzer using the 8414A Polar Display. The Smith Chart overlay permits direct readings of complex impedance values.

measurements become possible. The variety of "transducers' allows the user also to update his "mainframe" as measurement/test requirements change.

Accuracy of measurements

Hewlett-Packard network analyzers are built either as tracking receivers which convert the swept RF signal to a narrow-band constant IF signal or they use harmonic frequency conversion for obtaining a constant IF signal. In both cases, sensitive, low noise detection of the IF signal becomes possible. Furthermore, precision attenuators allow high resolution, accurate IF substitution measurements.

Speed of measurements

Hewlett-Packard network analyzers are capable of real-time swept displays (except for 8405A Vector Voltmeter and 4815A RF Impedance Meter). Swept measurements entail a substantial increase in speed of measurements compared to CW measurements. Also, they prevent oversights due to point-by-point techniques and make measurement results easier to interpret.

3575A

The 3575A measures Phase and Amplitude or Gain. With the 3575A, the complete response picture is available at a reasonable cost from a single instrument, over an 80 dB range, from 1 Hz to 13 MHz. The 3575A uses a broadband measurement technique, which is attractive because the measurement is not constrained by an internal tracking source or dedicated external device. The 3575A is not dependent on the wave shape, thus measurements can be made on a variety of waveforms such as, triangle and square waves. Noise and harmonic tolerance further enhances the range of measurement, so the instrument is useful under bench conditions.

3040A/3041A/3042A

The 3040A is a network analysis system capable of measuring amplitude and phase to 13 MHz. Group delay is an optional capability. The system consists of a synthesizer signal source and a two-channel tracking detector. The system has a 100 dB dynamic range, and measures amplitude to a resolution of .01 dB and phase to a resolution of .01° Measurement applications include filter design and production, amplifier testing, delay measurements on communications devices, and measurements on any linear two-port device.

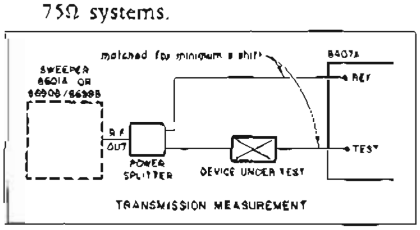
The 3041A extends the capabilities of the 3040A to semiautomatic use. The 3260A Card Reader provides control over all front panel functions such as frequency, level, and sweep. Repetitive tests can be done quickly and easily without operator error. The 3041A provides not only the amplitude, phase and group delay, but limit test and offset as standard features.

The 3042A is a fully automatic system which uses the Hewlett-Packard 9820A Calculator as a controller. The memory, computational power and decision making power of the calculator-controller extend the measurements to complex network solutions in the lab or rapid production line testing system. Accuracy can be improved by subtracting system errors from the measurements by using the memory and algebraic powers of the calculator.

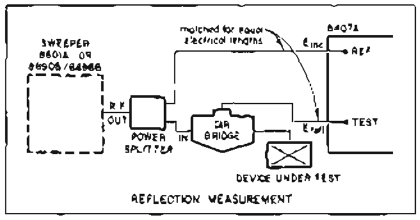
8407A

The 8407A Network Analyzer tracks the 8601A Generator/Sweeper (or 8690B/8698B Sweeper) from 100 kHz to 110 MHz. The 8407A achieves great versatility of measurements through a set of six different "transducers." Measurement capabilities include:

1) Transmission (gain, loss, phase shift) in 50Ω and 75Ω systems. Reflection (return loss, impedance) in 50Ω and 75Ω systems.



2) Complex impedance |Z|, Θ or R±jX over the wide impedance range 0.1Ω to >10 kΩ.
3) Voltage and current transfer functions (voltage or current gain, loss; phase shift).



4) High impedance in-circuit probing.
5) Visual comparison measurements with 0.01 dB, 0.2° resolution in 50Ω and 75Ω systems.
6) S-parameter measurements of active and passive linear networks (transistors) in 50Ω systems (also 75Ω systems for passive devices).

A rectangular and polar display and various CRT overlays permit direct readings of parameter values of interest. Applications are detailed in Application Notes 121-1, 121-2. Also, a videotape "8407 Network Analyzer System" #800475 is available.

4815A

To design a circuit for maximum power transfer and/or with desired frequency characteristics, engineers must know the impedance of the components they use. The 4815A RF Vector Impedance Meter provides direct readout of complex impedance values |Z| and Θ on adjacent meters thus greatly simplifying the measurement of impedance compared to conventional methods. Operating range of the 4815A is 1Ω to 100 KΩ and 0° to 360° over the frequency range 500 kHz to 108 MHz.

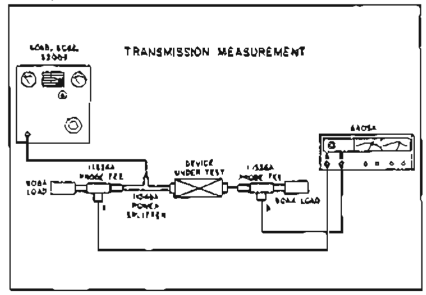
These operating characteristics are very similar to the 8407A/11655A impedance measuring system. The 8407A/11655A combination is superior to the 4815A with regard to accuracy (reactive probe parasitics of 11655A can be cancelled out), and also speed (real-time swept displays). However, the 4815A is lower priced.

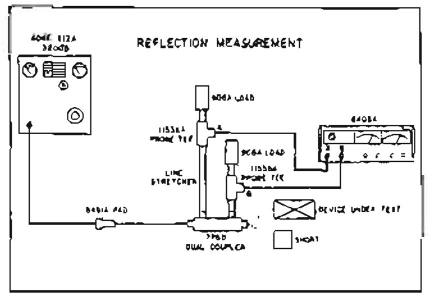
8405A

The 8405A Vector Voltmeter is a dual-channel RF millivoltmeter and phasemeter. It reads the absolute voltages on either of two channels and simultaneously determines the phase relationship between them. CW measurements are made over the frequency range 1 MHz to 1 GHz.

Besides its use as a voltmeter, applications of the 8405A include:

1) Transmission measurements (gain, loss, phase-shift) in 50Ω impedance systems. Reflection measurements (impedance, return loss) in 50Ω systems.





2) Group Delay, Amplitude Modulation Index
3) In-circuit probing
4) S-parameters in 50Ω systems

For detailed applications, Application Notes 77-1, 77-3, 77-4 and 91 are available.

8410A

The 8410A Network Analyzer System measures the transmission and reflection characteristics (S-parameters) of linear networks in the form of gain, attenuation, phase shift, reflection coefficient, normalized impedance in the frequency range 110 MHz to 40 GHz.

Harmonic frequency conversion from RF to a constant IF is accomplished by the 8411A Harmonic Frequency Converter operating from 110 MHz to 12.4 GHz; the 8411A Option H10 operates up to 18 GHz. In the frequency ranges 18-26.5 GHz (K-band) and 26.5-40 GHz (R-band), the K8747A and R8747A Reflection/Transmission Test Units use crystal mixers and a local oscillator to heterodyne the signals down into the range of the 8410A/8411A. In this manner, waveguide components can be characterized for S-parameters from 18 to 40 GHz.

The 8410A is a ratiometer, like the 8407A Network Analyzer, using both a reference and a test signal input. Consequently, the power from the sweeper must be split into two channels. This is accomplished by a "Test Set" whose other major function can be to provide the switching required for making transmission and reflection measurements with minimum or no changes in the measurement setup. Hewlett-Packard offers a total of twelve different test sets covering various frequency ranges and switching functions.

Another major instrument required in the 8410 measurement system is a unit for amplitude and phase detection and display. Hewlett-Packard offers three plug-ins for this purpose: a phase-gain indicator with a meter readout for CW measurements, a phase-gain display for displaying log amplitude and phase versus frequency, and a polar display displaying amplitude and phase in polar coordinates.

The 8410A is capable of sweeping octave bands through 18 GHz. Between 18 GHz and 40 GHz, 2 GHz frequency windows can be viewed. Measurements of more than 60 dB of attenuation and 40 dB of gain are possible. Another important facility is a line stretcher in the reference channel of the test sets, making possible equalization of electrical lengths in both channels for accurate differential phase measurements.

The variety of test sets, displays and accessories for measuring active devices makes the 8410A Network Analyzer adaptable to almost any measurement with regard to linear networks. For more detailed information, the videotape "8410 Network Analyzer System" #800473 is available.

8540 Series

An 8540 Series system couples the Network Analyzer's (8410A or 8407A) ability to completely measure the linear characteristics of a device with a computer's ability to completely setup a measurement, store data, and solve complex mathematics. As a result the automatic system can greatly improve:

1. The *SPEED* of the measurement (at least by a 5-20x factor).

2. The *ACCURACY* of the measurement through sophisticated error correction techniques which cannot practically be performed manually.

3. The *EASE OF OPERATION* and,

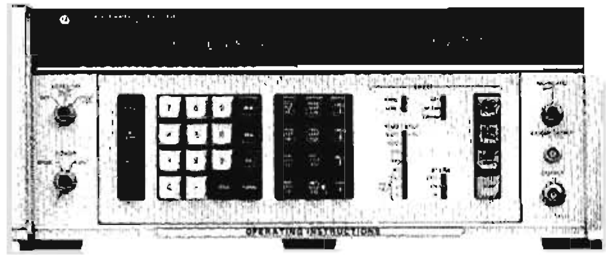
4. The *DATA OUTPUT FORMAT* which can be presented in the most useful manner (alphanumeric or graphic with hardcopy, cassette or CRT presentation).

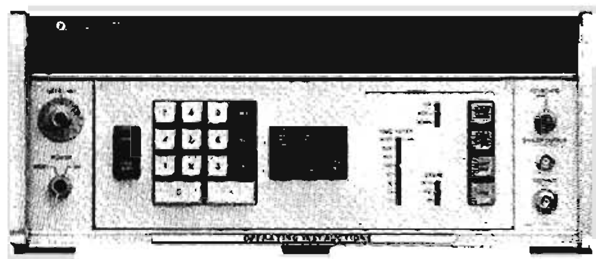
Data can be made readily accessible by computer-aided design programs which help the design engineer analyze the overall performance of a circuit based on subassembly measurement data.

Network Analyzer Summary

Model	Frequency Range	Source	Measurement Capabilities
3575A Gain/Phase Meter (Page 414)	1 Hz–13 MHz	None	Gain Phase and Amplitude Low Frequency Analysis
3040A Manual Network Analyzer (Page 407)	50 Hz–13 MHz	3320A/B or 3330A/B	Amplitude and Phase Optional Group Delay Gain or Loss
3041A Semiautomatic Network Analyzer (Page 409)	50 Hz–13 MHz	3330B Synthesizer	Amplitude, Phase, Group Delay Limit Test Offset Card Reader Control
3042A Automatic Network Analyzer (Page 411)	50 Hz–13 MHz	3330B Synthesizer	9820 Calculator Control Complex Network Analysis Decision Making Ability Computational Capability
676A Tracking Detector (Page 413)	10 kHz–32 MHz	675A Sweeping Signal Generator	Transfer Functions, Impedance in 50Ω, 75Ω systems Comparison Measurements of two networks in 50Ω, 75Ω systems Complex Impedance, 0.3Ω–3 kΩ
8407A Network Analyzer (Page 418)	100 kHz–110 MHz	8601A Generator/Sweeper 8690B/8698B Sweep Oscillator	Transfer Functions, Impedance in 50Ω, 75Ω systems Complex Impedance 0.1Ω to > 10 kΩ High Impedance In-Circuit Probing High Resolution Comparison Measurements in 50Ω, 75Ω systems S - parameters in 50Ω, 75Ω systems
4815A Vector Impedance Meter (Page 416)	500 kHz–108 MHz (CW)	Internal (external possible)	Complex Impedance, 1Ω to > 100 kΩ
8405A Vector Voltmeter (Page 417)	1 MHz–1 GHz(CW)	608E, F Signal Generator, VHF 612A Signal Generator, UHF 3200B Oscillator, VHF 8654A Signal Generator, UHF	Voltmeter Transfer Functions, Impedance in 50Ω systems Group Delay, Amplitude Modulation Index S - parameters in 50Ω systems
8410A Network Analyzer (Page 421)	110 MHz–40 GHz	8620 – Series Sweep Oscillator 8690 – Series Sweep Oscillator	Transmission/Reflection Characteristics in 50Ω systems S - parameters in 50Ω systems
8540 Series Automatic Network Analyzer (Page 426)	100 kHz–18 GHz	8690/8620 Sweep Oscillators	Automatic measurement of Transmission/reflection characteristics Full error Correction Virtually no programming required Versatile output: 28 parameter alphanumberic or graphic; hardcopy cassette or cathode-ray-tube.

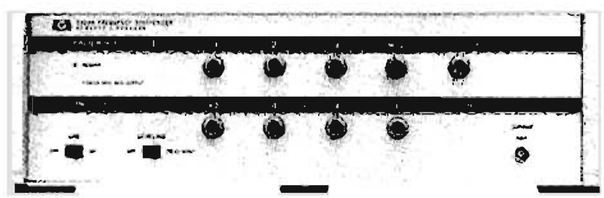
MANUAL NETWORK ANALYZER
Measures amplitude and phase response
Model 3040A

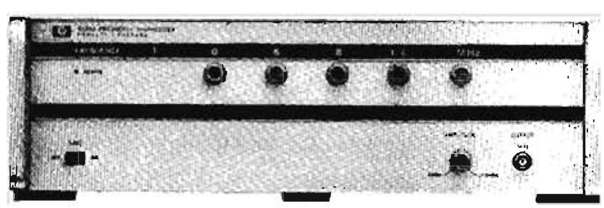

3330B


3330A


3570A

NEW


3320B


3320A

Description
The 3040A Network Analyzer System consists of any of four synthesizer sources (3320A/B or 3330A/B) and a selective detector, the 3570A. The synthesizer source provides both the signal stimulus and the tracking frequency information to the selective detector. The 3040A provides the capability to characterize linear two-port networks to 13 MHz. The 3040A Manual Network Analyzer provides measurements formerly available only on automatic systems. Sweeping of amplitude and frequency, internal calculation of group delay, and offset measurement capability are available as well as the standard measurement of amplitude and phase.

Wide dynamic range — high resolution
The 3040A provides 100 dB of dynamic range on each of three input ranges and has sensitivity on the lowest range to −120 dB V (1 microvolt). Measurement of amplitude is made to 0.01 dB resolution and phase to 0.01° resolution.

Selection of sources
The sources available (3320A/B and 3330A/B) allow the user a range of performance from three digit to eight digit

frequency resolution, and one part in 10^{-5} to one part in 10^{-9} frequency stability to precise amplitude level control. The 3330A/B sources also provide frequency sweep capability and permit the use of the 3570A group delay option. Further, the 3330B provides amplitude sweep capability.

SOURCE SELECTION CHART

	3320A	3320B	3330A	3330B
Freq. Range	0.01 Hz to 13 MHz in 7 ranges		0.1 Hz to >13 MHz	
Freq. Resolution	3 digit		8 digit	
Freq. Sweep	No		Yes	
Amplitude Range	+13 dBm to 0 dBm	+26 to −73 dBm	+13 dBm to 0 dBm	+13.44 dBm to −86.55 dBm
Amplitude Flatness	±2 dB	±0.05 dB	±0.5 dB	±0.05 dB
Amplitude Resolution	1 turn potentiometer	4 digits	1 turn potentiometer	4 digits
Amplitude Sweep	No		Yes	
Group Delay	No		Yes	
Digital Programming	BCD	BCD or ASCII	ASCII	

3040A Manual Network Analyzer

3570A Options	Description	Price
Opt. 100	Standard 50Ω 3570A	$5000
Opt. 101	Standard 75Ω 3570A	$5000
Opt. 102	50Ω Delay/Limit Test and Offset added to 3570A	add $ 400
Opt. 103	75Ω Delay/Limit Test and Offset added to 3570A	add $ 400
Opt. 104	Isolated ASCII Two-Way	add $ 500

3320A Options	Description	Price
Opt. 200	Standard 50Ω 3320A	$1900
Opt. 201	Standard 75Ω 3320A	$1900
Opt. 202	XTAL Oven (10^{-8}/day)	add $ 290
Opt. 203	BCD Remote Control	add $ 300
Opt. 206	100 Hz/10 Hz Ranges	add $ 200

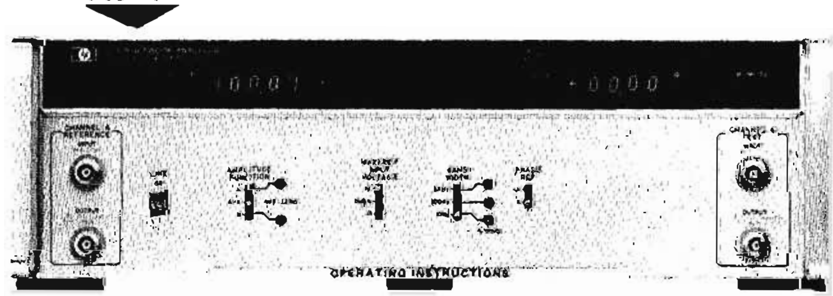
3320B Options		
Opt. 300	Standard 50Ω 3320B	$2550
Opt. 301	Standard 75Ω 3320B	$2550
Opt. 302	XTAL Oven (10^{-8}/day)	add $ 290
Opt. 304	BCD Remote Control	add $ 400
Opt. 306	100 Hz/10 Hz Ranges	add $ 200
Opt. 307	ASCII Remote Control	add $ 595

3330A Options		
Opt. 400	Standard 50Ω 3330A	$5100
Opt. 401	Standard 75Ω 3330A	$5100
Opt. 402	XTAL Oven (10^{-9}/day)	add $ 500
Opt. 403	Delete Standard XTL Oven	Subtract $ 200
Opt. 404	Isolated ASCII	add $ 225
Opt. 405	5 V/50Ω Output	add $ 250

3330B Options		
Opt. 500	Standard 50Ω 3330B	$6000
Opt. 501	Standard 75Ω 3330B	$6000
Opt. 502	XTAL Oven (10^{-9}/day)	add $ 500
Opt. 503	Delete Standard XTL Oven	Subtract $ 200
Opt. 504	Isolated ASCII	add $ 225
Opt. 505	5 V/50Ω Output	add $ 250

TRACKING DETECTOR
Used with 3040A, 3041A, 3042A network analyzers
Model 3570A

NEW



3570A

Description

The 3570A Tracking Detector is the selective detector in the 3040A, 3041A and 3042A Network Analyzers. The detector is a two-channel device with two outputs which provides stimulus signals derived from the system's synthesizer and two level measurement inputs. Level of both channels, Channel A or Channel B, can be measured in dB or the log difference B-A mode may be used to provide unreferenced or comparative measurements. Phase is measured as phase of Channel B with respect to Channel A. Amplitude is measured to 0.01 dB and phase to 0.01°.

Optional capability

Offset and group delay capability is available with the 3570A as an option. Measurements can be offset by arbitrary values, and deviations from the offset point can be measured. With the group delay option and either the 3330A or 3330B sources, group delay measurements can be made with resolution as small as 1 ns.

Specifications, 3570A

Frequency range: 50 Hz to 13 MHz.

Channel A and B outputs: electrically identical—equal in frequency and amplitude to the signal generator output. Output impedance: 50Ω or 75Ω ±2%. Maximum output: 1 V rms into 50Ω or 75Ω.

Channel A and B inputs: electrically identical—both tuned to the signal generator's frequency. Input impedance: 1 MΩ ±2% shunted by 30 pF nominal. Input signal range: 1 V rms to 1 μV rms. Input selectivity: 10 Hz, 100 Hz and 3 kHz bandwidths.

Amplitude measurements: dB measurement reference selectable; 1 V, 0 dBm, or .1 V reference. Measurement range: 100 dB below selected reference. Display resolution: 0.01 dB. Display range: 0 to −100 dB below reference setting (using A or B "Amplitude Function").

−100 dB to +100 dB (using B-A "Amplitude Function").

−199.99 dB to +100.99 dB (with offset option).

Amplitude accuracy: (25° ±5°C).

Absolute: no spec—may be calibrated to source using front panel adjustments.

Relative: A, B or B-A "Amplitude Function."

0 dB	−20 dB	−80 dB	−100 dB
±0.2 dB	±0.5 dB	±1.5 dB	

Frequency response: A or B "Amplitude Function"; ≤0.5 dB p-p error. B-A "Amplitude Function"; ≤0.1 dB p-p error.

Phase measurements: phase reference is phase reading in reference Channel A.

Display resolution: 0.01°.

Display range: −179.5° to +179.5° (display recycles).

A/-A reference offset: 180° ±0.1°.

Phase accuracy: (25° ±5°C)—channel B within 6 dB of Channel A.

Phase linearity: ±0.2°.

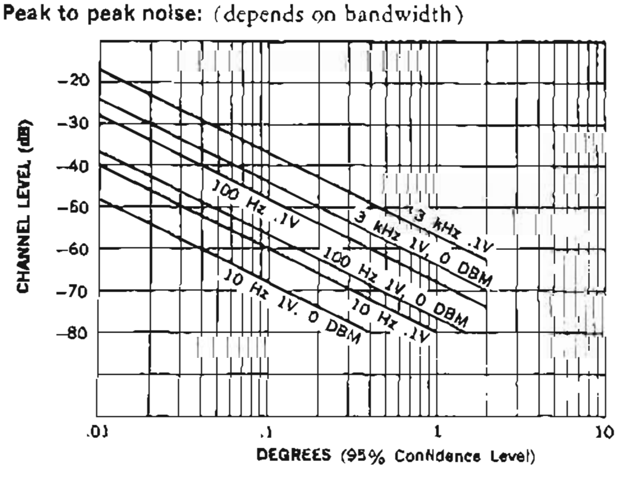
Frequency response: (channels at 0 dB).

±.8°	±.2°	±1°	
50 Hz	100 Hz	1 MHz	13 MHz

Amplitude response

±.4°	±.6°	±1°	No spec	
0 dB	−20 dB	−70 dB	−80 dB	−100 dB

Peak to peak noise: (depends on bandwidth)



Analog outputs (rear panel)

Amplitude function

DC voltage is proportional to the logarithmic amplitude response in Channel A, Channel B or B-A. (0 to ±10 V dc for 0 to ±100 dB, 0.1 V/dB).

Output impedance: 1 kΩ ±10%.

Phase/Delay

DC voltage proportional to phase response or group delay. Phase (0 to ±9 V dc for 0 to ±180°, 0.05 V/°).

Delay (0 to ±10 V for 0 to 2,000 counts of delay, 5 mV per count).

Output impedance: 1 kΩ ±10%.

Delay (X-Y recorder)

This X-Y recorder output should be used when plotting delay. Same voltage range as the regular delay analog output.

Output impedance: 1 kΩ ±10%.

Digital outputs

Internal A to D converter provides digital outputs of amplitude, phase and delay. The front panel readouts of amplitude, phase and delay are also driven by the A to D converter. All digital outputs are ASCII coded, TTL, low true logic.

Z-Axis output

Provides markers during frequency sweeps and amplitude sweeps. Intensify center frequency, 11 evenly spaced markers, or limit points.

Blanking voltage: 10 V dc ±10%.

Unblanking voltage: 0 to 7 V dc ±10% (adjustable).

Output impedance: 1 kΩ ±10%.

Options

50Ω or 75Ω—Output Impedance and Input Reference. (Factory installation only).

Channel A and B output impedance is 50Ω or 75Ω.

0 dBm on "Max/Ref Input Voltage" switch is referenced to 50Ω or 75Ω.

50Ω Delay/Limit Test and Offset Measurements. (Factory installation only).

Delay measurement

$$D_T = \frac{\phi_1 - \phi_2}{360^\circ (f_2 - f_1)}$$

Frequency resolution: twenty choices from 5 Hz to 200 kHz in a 5, 10, 16.6, 20 sequence.

Measurement range: five ranges; 19.999 μs, 199.99 μs, 1.9999 ms, 19.999 ms, and 199.99 ms.

Delay sensitivity from 1 ns to 10 μs depending on measurement range in use.

Delay accuracy: ±(% of reading + % of range)

0 dB	−40 dB	−80 dB	−100 dB
±(0.2% + 0.2%)	±(0.5% + 0.5%)	no spec	

Limit test: limit tests may be made on amplitude, phase and delay.

Limit stop mode: stops when a limit transition occurs.

Limit no-stop mode: analyzer continues making measurements after a limit point is crossed.

Offset measurements: enter an offset from either the front panel or remotely. Amplitude phase and delay measurements can be offset. Arbitrary offsets can also be entered remotely.

75Ω Delay, Limit Test and Offset Measurements. (Factory installation only).

Same as above except measurements are referenced to 75Ω.

ASCII Isolated Two-way.

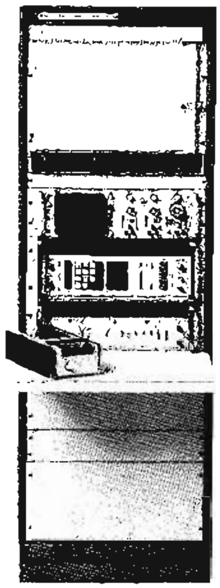
Digital input and output lines are electrically isolated from signal ground.

DC isolation: ±250 V.

AC isolation: >30 dB, 0 to 1 MHz.

For field installation, order accessory kit HP 11176A.

SEMIAUTOMATIC NETWORK ANALYZER
Card reader controlled analysis
Model 3041A


NEW▶

3041A

Description

The 3041A Semiautomatic Network Analyzer consists of three instruments: 1) the 3570A Tracking Detector, 2) the 3330B Automatic Synthesizer and, 3) the 3260A Marked Card programmer, all installed and tested in the 29402B Instrument Rack. The system has the same amplitude and phase specifications as the 3040A, but has the semiautomatic control and added functional capability offered by the marked card programmer.

Easy programmability

The marked card programmer provides a convenient means of performing semiautomatic measurements for production tests or other situations where quick, repeatable, error-free data entry and test setup is required. The 3260A Card programmer accepts both marked or punched cards which can be easily coded to control any of the front panel functions of the 3330B Synthesizer or 3570A Tracking Detector. Entry of a variety of frequencies, and amplitudes to perform a series of measurements becomes a simple matter of inserting a card into the 3260A. In addition, the system provides programmable limit test, offset, and group delay as standard equipment.

Limit test, offset, group delay

The 3570A Detector can accept sets of hi and lo limits from the card programmer, and provide front panel indication of whether or not the measured parameter lies within the prescribed bounds. Thus, production tests can be carried out quickly and easily utilizing only the hi, go, or lo indications.

Measured values can be offset by current readings or by arbitrary values by the single entry of a card. In this way, devices can be tested with respect to their deviations from prescribed values. For example, filter passband ripple can be measured directly without tedious correction for insertion loss, merely by offsetting the measurement by the amount of the loss. Group delay can also be easily programmed and measured using the marked card programmer.

3330B Automatic Synthesizer

The 3330B is a high resolution frequency synthesizer. The synthesizer has a frequency range from .1 Hz to 13 MHz with a resolution of .1 Hz and stability of one-part in 10^{-8}. Amplitude range is from +13.44 dBm to −86.55 dBm into 50Ω with 0.01 dB resolution. Full specifications for the 3330B can be found on page 330.

3260A System Controller

The controller for the 3041A Semiautomatic Network Analyzer is the 3260A Marked Card Programmer. This easy to use controller is useful for remotely programming all front panel controls on the 3330B Automatic Synthesizer and 3570A Tracking Detector.

Each key and slide switch position has a seven-bit ASCII word assigned to it. Programming consists of setting up a measurement manually, and when satisfactory results are obtained . . . simply recall and write down the sequence in which the various keys and switches were used. Next, with easy to use code tables, convert the sequence to ASCII words and mark or punch these words on 3260A program cards. This same test can now be performed with absolute repeatability and freedom from operator error, simply by inserting the card in the 3260A.

3041A Includes

3330B Automatic Synthesizer.
3570A Network Analyzer with Group Delay/Offset Limit test.
3260A Marked Card Programmer.
29402B Rack with fixed shelf and filler panels.
11171A/B Front Panel Accessory Kit.
Cable kit (11236B/11170C/11172A)
Operating and programming manual and service manual.
System assembly and checkout at factory.

3041A Options

Option 103, 7044A X-Y Recorder.

Obtain hard copy results of amplitude and phase/delay measurements with fast X-Y Recorder. All connections are made to the rear of this rack mounted recorder in the 3041A rack.

Option 104, 1201B Oscilloscope

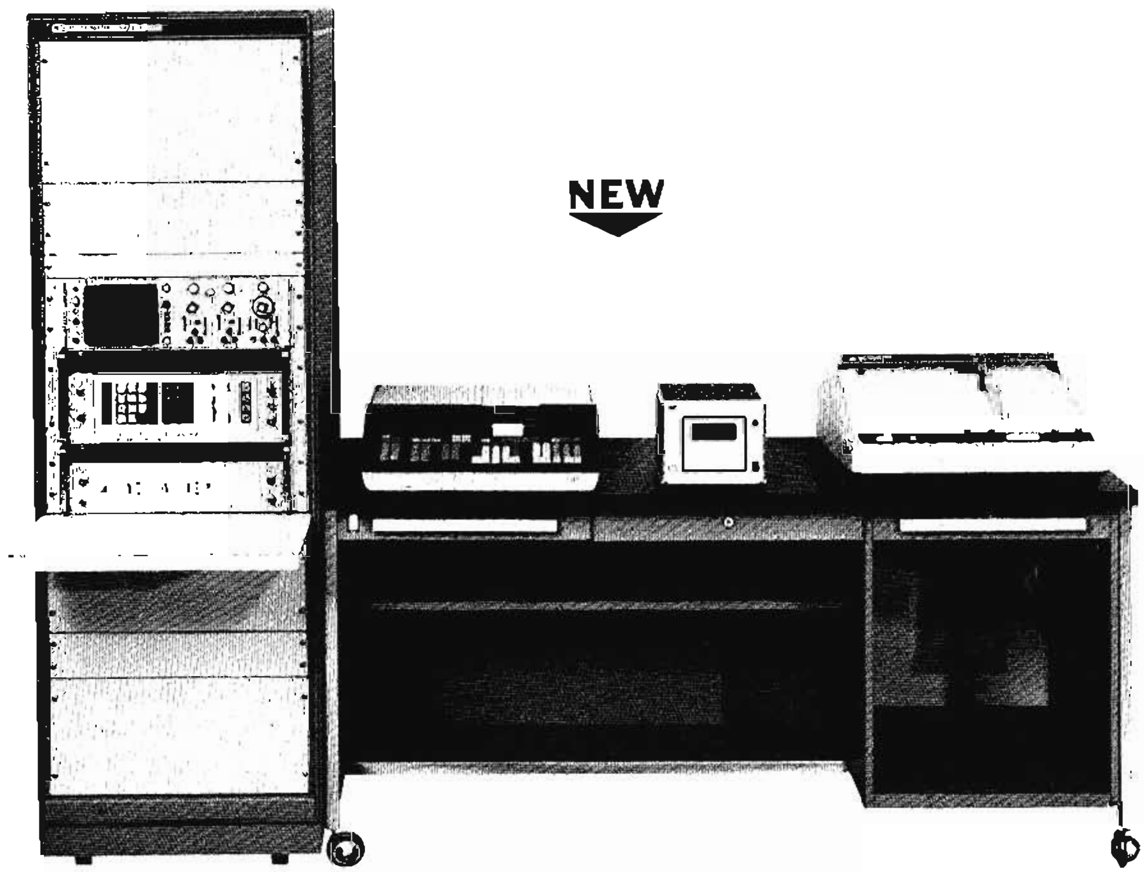
Two channel, variable persistence scope for convenient display of amplitude and phase/delay measurements. All connections are made to the rear in the 3041A rack.

3041A Semi-Automatic Network Analyzer

3041A Option	Description	Price
Opt. 100	Standard 50Ω System	$14,000
Opt. 101	Standard 75Ω System	$14,000
Opt. 102	Isolated ASCII Input/Output (required when connected to computer or 9820A)	add $ 725
Opt. 103	7044A X-Y Recorder with switch panel for RTIP	add $ 1,550
Opt. 104	1201B Oscilloscope 10 x 10 div. scale, RTIP	add $ 2,150
Opt. 105	230 V Powerline version (50-60 Hz)	no additional charge
Opt. 106	XTAL oven (10^{-9}/day)	add $ 500

AUTOMATIC NETWORK ANALYZER

Analysis under calculator control
Model 3042A



3042A

Description

The 3042A Automatic Network Analyzer provides a level of control and performance never before available in this price range. The 3570A Tracking Detector and the 3330B Automatic Synthesizer in the 29402B Instrument Rack are under the control of the HP Model 9820A Calculator.

All the measurement capability described on pages 407 through 410 on the 3040A and 3041A systems can be performed automatically by utilizing the easy to use programs in the 9820A Calculator.

In addition to providing increased control and data logging ability to the system, the calculator can be programmed to make decisions based on the measured data and improve the performance of the system by such routines as subtracting out any system errors to provide more accurate measurements.

Solve problems

In the Design Lab. Fully automatic measurements can be made by utilizing the calculator based 3042A system. The computing capability of this system makes it ideal for use in the design lab. In addition to analyzing hardware automatically, the 9820A Calculator is useful for solving cumbersome design equations.

In Production. The 3042A Network Analyzer's automatic measurement capability makes production testing faster and gives outstanding repeatability. Operator interaction can be on the level of entering test parameters and answering questions asked by the calculator, such as "IS DEVICE IN FIXTURE", or can be made as simple as pressing a single key on the calculator keyboard to initiate entire sophisticated tests.

Automatic data analysis is a powerful tool in production. The 3042A can easily manipulate data for use in QA or yield analysis, and for use in making performance decisions on the device under test. GO/NO GO testing speeds up production tests even more and reduces operator errors.

In Calibration and Adjustment Procedures. The network analyzers offer accuracy, repeatability and ease of control . . . three important criteria for calibrations and adjustments. Analog outputs of all measurement parameters, coupled with the optional display device, make dynamic adjustment possible.

Calculator control in the 3042A can aid the operator in making adjustments. The calculator can tell the operator which adjustment to make resulting in faster tests, plus reduced operator errors.

Calculator control

The 9820A Calculator is the controller for the 3042A Automatic Network Analyzer. This capable desk-top calculator allows you to design a remote controlled network analyzer with built-in data analysis to meet your specific needs.

System programming is done from the easy to understand user language keyboard and magnetic card program storage. The 9820A Calculator takes advantage of the two-way data flow on the ASCII interface bus to input readings from the 3570A for data logging and automatic data analysis.

New interface structure

The ease of control and tremendous capability of the 3042A System is due, in part, to the new Hewlett-Packard ASCII interface bus. This is a bus structure which allows 15 wire parallel connection of instruments and controllers. All devices are addressable and may have both listen and talk capability. Program information and data are transmitted in character serial form in an eight bit ASCII code. This system vastly simplifies the interface structure and the problem of communication and control between instruments.

3042A Programs and Documentation

The 3042A derives much of its great accuracy, speed and ease of use through a set of powerful, ready-to-use programs supplied with the system. These general purpose programs can easily be modified to your specific application by an operator with little or no prior programming experience. Easy-to-use program editing of the English and algebraic language 9820A Calculator, plus the structure of the supplied programs, makes your software requirements fast and economical. The 3042A's program library includes diagnostic programs used for verifying performance, routine maintenance, and automatic troubleshooting to the instrument level.

3042A includes

3330B Automatic Synthesizer with Isolated Remote.
3570A Network Analyzer with Isolated Remote.
9820A Calculator, Option 001 429 Data Registers.
11221A Math ROM block for calculator.
11145A 3042A Interface kit—I/O card, ROM, cables, and software including verification and diagnostics.
11171A/B Front Panel Accessory Kit.
Cable Kit (11236B/11170C/11172A).
29402B Rack with fixed shelf and filler panels.
Operating and programming manual.
Service manuals.
System assembly and check out at the factory.

3042A options

Option 102, Group delay/limit test/offset added to 3570A

Recommended when it is required to make these measurements within the 3570A rather than calculate them with the 9820A.

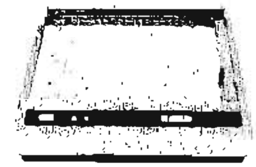
Option 104, 1201B Oscilloscope

Two channel, variable persistence scope for convenient display of amplitude and phase measurements. All connections are made to the rear in the 3042A rack.

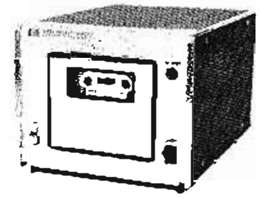
3042A Recommended Accessories

9862A Plotter

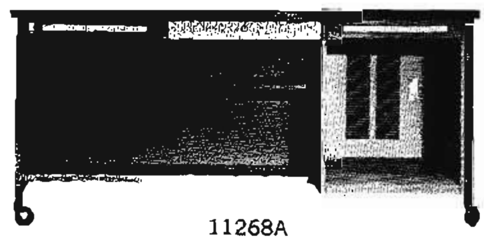
Obtain hard copy plots of all measurements, as well as 9820A calculations and data analysis.



9862A



9865A



11268A

9865A Cassette Memory

Use where convenient, reliable storage of 9820A programs or 3042A measurement data is required. 6000 data registers or 48,000 program key strokes are provided with numbered file search capability. Requires 11223A Cassette Control Block in 9820A.

9861A Typewriter

Ideally suited for producing finished test reports, completely documented problem solutions or typing on preprinted forms all under automatic control of the 9820A.

11222A User Definable Functions Block

Permits definition of up to 15 or the keys in the left-hand key blocks of the 9820A with special user functions and sub-programs.

11268A Calculator System Table

9820A and any two peripherals set on top of table. Work space and built-in power strip add operator convenience.

3042A Automatic Network Analyzer

3042A Option	Description	Price
Opt. 100	Standard 50Ω System	$22,900
Opt. 101	Standard 75Ω System	$22,900
Opt. 102	50Ω delay/Limit test/Offset added to 3570A	add $ 400
Opt. 103	75Ω delay/Limit test/Offset added to 3570A	add $ 400
Opt. 104	1201B Oscilloscope 10 cm x 10 cm scale, RTIP	add $ 2,150
Opt. 105	230 V Powerline version (50-60 Hz)	no additional charge
Opt. 106	XTAL oven (10^{-9}/day)	add $ 500

NETWORK ANALYZER
80 dB amplitude response/360° phase
Models 675A/676A

Network Analyzer, 675A & 676A

This network analyzer provides swept phase and amplitude information over the 10 kHz to 32 MHz frequency range. Both laboratory and production oriented, the 675A Sweeping Signal Generator and 676A Phase/Amplitude Tracking Detector system provides an amplitude response with 80 dB dynamic range, accompanied by 360° (or multiples of) phase measurement capability.

Frequency

The 675A frequency can be manually positioned, automatically swept between two preset limits, or swept about a center frequency in calibrated increments. A bypass marker system superimposes markers on all phase and amplitude channels for easy frequency identification and calibration. 100 kHz and 1 MHz comb markers and up to five individual single frequency markers are available in the 100 kHz to 32 MHz range.

When used with a low frequency oscilloscope or X-Y recorder, the network analyzer presents displays that can be calibrated in frequency, phase, and amplitude. Along with the low residual FM (<70 Hz peak), low spurious response and low noise (−85 dB), these capabilities permit accurate measurements of devices with steep responses.

Amplitude and phase

The 676A is a dual channel detector synchronously tuned to the sweep frequency. Four scope outputs (A, B, A-B, PHASE A-B) are located on the front panel of the detector. A and B provide 80 dB of log amplitude dynamic range (50 mV/dB) for each channel, and A-B is the log difference between the two channels. All three present information in linear dB. PHASE A-B is a dc voltage that is linearly proportional (10 mV/degree) to the phase difference between channels from 0° to 360°.

To make using an oscilloscope or recorder more convenient, a "CAL" is provided for the scope outputs to allow fine adjustment of the display. Phase is also conveniently calibrated using the 5° to 100° "PHASE CAL CHECK" buttons. Either pushbutton supplies a calibrated dc offset to the vertical input of the oscilloscope allowing a quick check of phase and calibration of the display.

Specifications, (675A and 676A)*

Frequency range: 10 kHz to 32 MHz in one range with Start-Stop, Manual, Center Frequency Sweep, and CW control. Digital drum readout, 1 kHz settability, 20 kHz resolution.

RF output (Channels A and B): two equal-amplitude, in-phase outputs derived from 675A output through resistive power divider.

- **Level (676A only):** +2 dBm (0.28 V rms) into 50Ω with 675A set to +13 dBm. Adjustable with 675A attenuator.
- **Impedance:** 50Ω (75Ω on request). NOTE: impedance independent of 675A. Impedance of 675A must match impedance of 676A.
- **Output isolation:** 16 dB between channels.

RF input (Channels A and B): identical inputs synchronously tuned to 675A output frequency.

- **Level:** +2 dBm max (not to exceed +13 dBm or 1 V rms).
- **Impedance:** same as RF output.
- **Crosstalk:** >84 dB between channels.

Amplitude functions

Range: 0 to −80 dBm.

Accuracy

- **Using Channel A or B:** output proportional to log of input ±1.5 dB over 80 dB dynamic range.

675A/676A

System flatness

- **Using Channel A or B:** ±0.8 dB, 10 kHz to 200 kHz, 675A unleveled; ±0.8 dB, 200 kHz to 32 MHz, 675A internally leveled.

Noise: < −85 dB (50Ω source impedance).

Spurious responses: < −85 dB (50Ω source impedance).

Channel A and B scope output: 50 mV/dB (+4.2 V dc for +2 dBm input level) adjustable with CAL control.

Phase function

Range: 0° to 360°. Display recycles every 360°, internal phase shifter allows 0° to 360° continuous phase offset.

Accuracy

- **As a function of frequency:** 100 kHz to 32 MHz, ±1°; 10 kHz to 100 kHz, ±2°.
- **As a function of amplitude:** ±5° over entire 80 dB dynamic range.
- **Calibrator accuracy:** 100° ±1.0°, 5° ±0.2°.

Phase scope output: 10 mV/° (1.80 V dc ±1.80 V dc for 180° with phase control set to 0°). Adjustable with CAL control.

General

Operating temperature: 0°C to 50°C.

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz.

Dimensions (675A): 16¾" wide, 8¾" high, 18⅜" deep (425 x 221 x 467 mm); (676A): 16¾" wide, 3-15/32" high, 18⅜" deep (425 x 88 x 467 mm).

Total system weight: net, 59 lbs (26,3 kg); shipping, 83 lbs (37,4 kg).

Total system power: 185 VA max.

Price (must order 676A and 675A for network analyzer system): HP 676A, $1625; HP 675A, $2575.

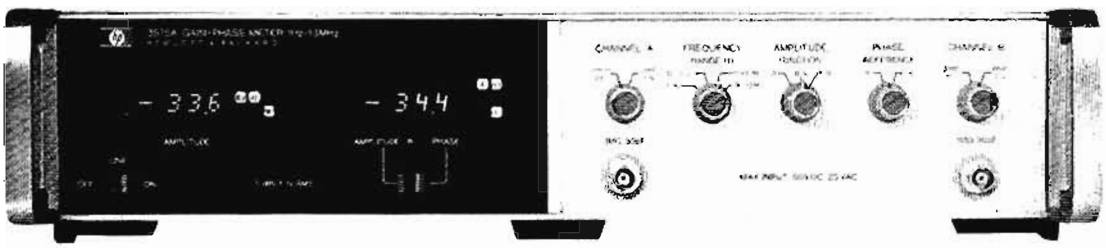
- **HP 675A Option 001** (includes 1 MHz harmonic comb marker), add $75.
- **HP 675A Option 002** (includes 100 kHz harmonic comb marker), add $75.
- **HP 675A Option 003** (includes 1 MHz and 100 kHz harmonic comb markers), add $125.

* Refer to data sheet for complete specifications.

GAIN/PHASE METER

Measure dB V and dB ratio from 1 Hz to 13 MHz

Model 3575A



3575A

NEW

Description

HP's 3575A Gain/Phase Meter is a basic instrument used for making network measurements over a seven decade frequency and 100 dB amplitude range. Because it isn't dependent on sweeping sources or dedicated displays, a number of different instrument configurations are possible. While allowing variations in the basic phase and amplitude setups, the flexibility also implies applications in such measurements as impedance, delay and complex root location.

Phase in degrees and amplitude in dB or dB V are the outputs. The phase and amplitude information is available from a LED digital readout, analog outputs on the rear panel, or BCD outputs in Option 002 or 003. The phase and amplitude readings can be plotted by hand on log paper to give a Bode plot. Alternatively, the analog outputs can be used to drive an X-Y recorder to give the same plot faster and for more points. As a third choice, a storage scope can be used to display the frequency response. As a fourth alternative, the BCD information can be used by a computer or HP calculator.

Phase

To measure phase, two input signals are necessary. One input is used for a reference signal. The other channel monitors the phase shifted signal. Both input channels have identical high impedance input circuits, so circuit loading is compensated and low voltage signals can be used on either channel. To reduce phase errors that are caused by capacitive loading, a 10:1 low capacitance scope probe or a low impedance termination can be used. The 10:1 probe is also useful for extending the voltage range to 200 V.

Phase angles are measured by looking at the time difference between successive zero crossings of the two input signals. Because zero crossings are the only significant information used, the shape of the waveform away from zero is not significant. Square, triangle and distorted waveforms will all give the same answer as a sine wave.

Harmonics

The 3575A has been designed so even harmonics cannot cause phase measurement errors. In-phase, odd harmonics will not cause error either. This is an important instrument feature because the input signals always have some harmonic content. Most oscillators have harmonics 40 dB below the fundamental. With this amount of harmonic content, phase errors could result. However, the 3575A has been designed so errors from input signals are commensurate with the basic accuracy of this instrument; thus, the effects of harmonics don't become a concern to the user.

Noise

HP's 3575A has unique logic circuitry (patent applied for) which makes it tolerant of noise. This important feature keeps the digits from racking when using low level signals. Without this feature, it would not be possible to get unambigious readings at the lower amplitude range of the instrument.

Besides being tolerant of noise, the 3575A is also able to reject noise. A front panel switch selects the appropriate three-decade frequency range. By covering three decades, plots and sweeps can be made without repeated adjustment and, at the same time, noise rejection is still achieved.

The 3575A can be used over its wide amplitude and frequency ranges in the presence of noise and harmonics without external signal conditioning.

Amplitude

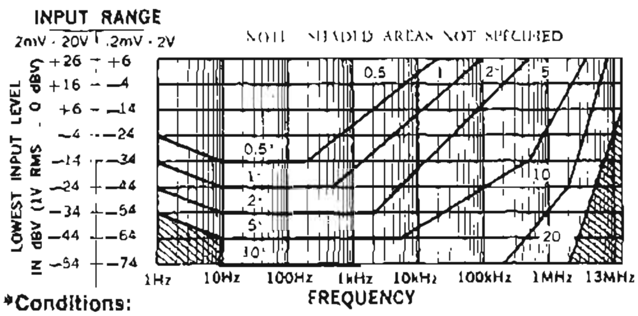
Amplitude measurements fall into two categories. The amplitude of either channel or the ratio can be measured. The channel measurements are in dB where 0 dB V = 1 V rms. Measurements of the ratio are in dB where 0 dB means the channel levels are the same. If the input signal level is too low for the phase or ratio functions to operate, a measurement of the channel amplitude will reveal this. If the level is too high, the digits will be blanked and the overload annunciator will indicate which channel is in overload.

To achieve a wide dynamic range without internal or external ranging, a wide dynamic range log amplifier was developed. It uses eight log segments to achieve an 80 dB range. The 20 dB attenuator associated with each channel allows 100 dB of signal difference.

The amplifier in both channels continuously logs the input signal. The logged signals are then rectified to give a dc voltage that is proportional to the log of the input. With the two dc signals available, it is possible to measure either the level of Channel A or B or by subtracting the dc voltages to obtain the log ratio. Using this technique, the amplitude ratio of waveforms at different frequencies or different waveforms can be measured.

The technique of subtracting Channel A from B directly yields the gain or loss through a network. The advantage of measuring input and output to find gain is that the input stimulus isn't required to have a flat frequency response. The stimulus can also have a distorted waveshape without affecting results. The Bode plot is then independent from the stimulus and in-circuit measurements are possible.

Specifications



***Conditions:**

Temperature: 25°C ±10°C.

Frequency range switch on lowest applicable range.

Analog output accuracy (rear panel).

Input signal range: 200 μV rms to 20 V rms.

Harmonic rejection

Even harmonics no error.

Odd harmonics in phase no error.

Odd harmonics out of phase 0.57° worst case error when total odd harmonic distortion is 40 dB below the fundamental.

Noise tolerance: 2° error for a 10 kHz, 1 V sine wave on one channel. One volt sinewave added to Gaussian noise (limited to a 1 MHz bandwidth and 30 dB S/N ratio) on the other channel. The 100 Hz to 1 MHz frequency range was used.

Display

Range: ±180° with 12° of overrange.

Resolution: 0.1°.

Panel meter accuracy: ±3 counts (0.3 degrees, 0.3 dB/dB V). The panel meter error must be added to the phase and amplitude errors to obtain the display error.

Inputs

Impedance: 1 MΩ 30 pF.

Protection: ±50 V dc, 25 V rms.

Response time to achieve 90% of final reading:

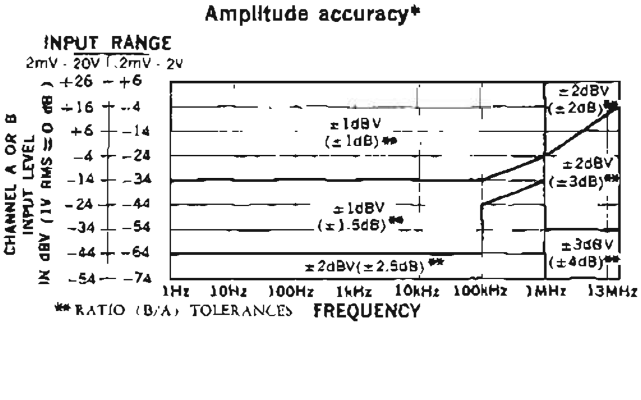
Frequency range	Time
1 Hz to 1 kHz	20 s
10 Hz to 100 kHz	2 s
100 Hz to 1 MHz	0.2 s
1 kHz to 13 MHz	20 ms

Rear terminal inputs are available as a special (3575A-C09).

Digital (Opt 002).

0, +5 ground true. 12 lines to fully program all functions.

Amplitude accuracy*



***Conditions:**

Temperature: 25°C ±10°C.

Accuracy applies to dB V and ratio measurements with the same frequency on both channels.

For ratio measurements, the lowest level channel determines accuracy.

Analog output accuracy (rear panel).

Amplitude functions: A dB V, B dB V or B/A dB.

Amplitude reference: (A dB V, B dB V) 1 V rms = 0 dB V.

Display

Range

A dB V, B dB V: −74 dB V to +26 dB (in two ranges).

B/A dB: −100 to +100 dB. (Both input signals must be within the range of 0.2 V rms to 20 V rms.)

Resolution: 0.1 dB V, 0.1 dB.

Outputs

Analog

Phase: 10 mV/degree.

Amplitude: 10 mV/dB or dB V.

Output Impedance: 1 kΩ.

Digital (Opt 002)

0, +5 V ground true. 31 output lines (1-2-4-8 BCD).

Digital readout

3½ digits with sign and annunciators. Four readings per second, fixed.

Options

001 dual panel meters

The 3575A Opt 001 is equipped with two digital readouts and two analog outputs for simultaneous amplitude and phase readings. This option has no additional measurement capability over the standard instrument.

Dual analog outputs: rear panel BNC connectors provide dc output voltages that correspond to the respective panel meter readings.

002/003 programmable

3575A Opt 002 and Opt 003 are equipped with dual panel meters and dual analog outputs (same as Opt 001) plus BCD outputs and complete remote control capability. Option 002 has negative true output levels and Opt 003 has positive true output levels. BCD information from the 3575A (Opt 002) can be read by the 9810 or 9820 HP Calculators with the 11203A BCD card.

General

Power: 115 V/230 V ±10%, 48 Hz to 440 Hz, 40 W.

Weight

net: 18.4 lbs (8,3 kg).

shipping: 25 lbs (11,3 kg).

Dimensions: 16¾″ wide, 3-15/32″ high, 13¼″ deep (425 x 88 x 337 mm).

Price

HP 3575A, $2450.

Opt 001 Dual Readout, add $400.

Opt 002 Programmable (negative true output levels), add $720.

Opt 003 Programmable (positive true output levels), add $720.

Accessories furnished

Rack mount kit

Extender boards

Line cable

50-pin connector (Opt 002 and 003 only)

Accessories available

10001A 10:1 Voltage Divider Probe

11048C 50Ω Feed-thru Termination

11094B 75Ω Feed-thru Termination

11095B 600Ω Feed-thru Termination

11203A (Option A05) BCD card for 9810 and 9820 Calculator

RF VECTOR IMPEDANCE METER

Quickly, easily measure Z & θ, .5 to 108 MHz

Model 4815A

Advantages:

- Direct reading of impedance and phase
- Convenient probe for in-circuit measurements
- Self calibration check provides measurement confidence
- Analog outputs for data recording
- Low-level test signal minimizes circuit disturbance

The HP 4815A RF Vector Impedance Meter provides all of the convenience of "probe and read" measurements. In use, the probe is connected directly into the circuit to be evaluated, frequency is selected, and complex impedance is read. This type measurement allows a straightforward adaptation to various jigs and fixtures for special measurements. Where only component values are to be determined, a quick-mount adapter is provided to allow rapid measurements. For critical component applications, the unit to be evaluated may be mounted directly in its working circuit and its value determined in its actual environment, at the frequency of interest.

Specifications

Frequency

Range: 500 kHz to 108 MHz in five bands: 500 kHz to 1.5 MHz, 1.5 to 4.5 MHz, 4.5 to 14 MHz, 14 to 35 MHz, 35 to 108 MHz.

Accuracy: ±2% of reading, ±1% of reading at 1.592 and 15.92 MHz.

RF monitor output: 150 mV minimum into 50 ohms.

Impedance magnitude measurement

Range: 1 ohm to 100 k ohms; full-scale ranges: 10, 30, 100, 300, 1 k, 3 k, 10 k, 30 k, 100 k ohms.

Accuracy: ±4% of full scale $\pm\left(\frac{f}{30\text{ MHz}}+\frac{Z}{25\text{ k ohms}}\right)$ % of reading, where f = frequency in MHz and Z is in ohms; reading includes probe residual impedance.

Calibration: linear meter scale with increments 2% of full scale.

Phase angle measurement

Range: 0 to 360° in two ranges: 0 ± 90°, 180° ± 90°.

Accuracy: $\pm\left(3+\frac{f}{30\text{ MHz}}+\frac{Z}{50\text{ k ohms}}\right)$ degrees; where f = frequency in MHz and Z is in ohms.

Calibration: increments of 2°.

Adjustments: front panel screwdriver adjustments for Magnitude and Phase Zero.

Recorder outputs

Frequency: 0 to 1 volt from 0 to 1 k ohm source, proportional to dial rotation.

Impedance magnitude: 0 to 1 volt from 1 k ohm source.

Phase angle: 0 ± 0.9 volt from 1 k ohm source.

Dimensions: 16¾" wide, 7¼" high, 18¾" deep (426 x 185 x 476 mm).

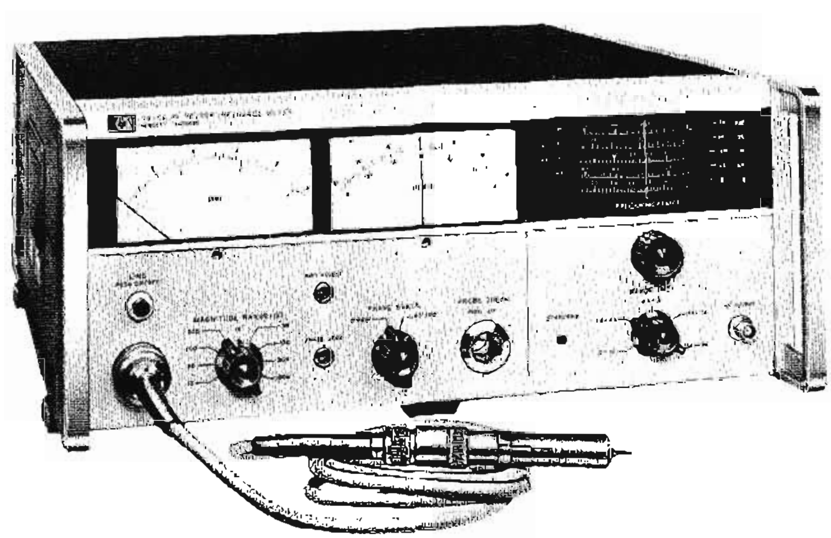
Weight: net 39 lbs (17,6 kg), shipping 55 lbs (24,8 kg).

Power: 105 to 125 V or 210 to 250 V, 50 to 400 Hz, 50 W.

Accessories furnished:

1. 00600A Probe Accessory Kit: contains BNC Type "N" adapter, Probe Socket, 00601A Component Mounting Adapter, 2 probe center pins, probe ground assembly.
2. Rack Mount Kit.

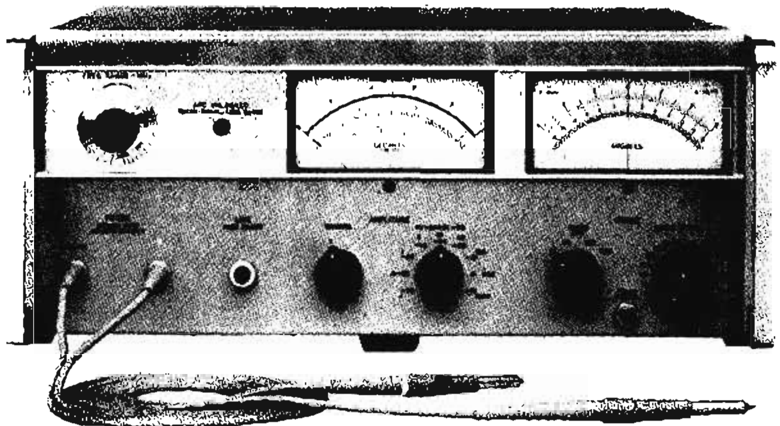
Price: HP 4815A, $2800.



VECTOR VOLTMETER

Accurate voltage, phase measurements, 1-1000 MHz

Model 8405A



8405A

Description

The 8405A Vector Voltmeter measures voltage vectors described by both magnitude and phase. This capability makes the 8405A a unique instrument for about any design and test application in the frequency range 1 to 1000 MHz.

In addition to absolute voltage measurements, capabilities include insertion loss and group delay of passband-filters and other transmission devices, gain and phase margin of amplifiers, complex impedance of mixers, antennas, matching the electrical lengths of cables, s-parameters of transistors, amplitude modulation index, RF distortion measurements, and in-circuit probing.

The 8405A achieves this measurement versatility through its two-channel capability enabling voltage magnitude measurements in either channel, thus allowing ratio measurements, and phase difference measurements between the two channels. Gain or loss in excess of 90 dB and phase measurements with 0.1° resolution over a 360° phase range are possible.

Accuracy is achieved through the 1 kHz bandwidth entailing response only to the fundamental frequency of the input signal. Also, phase-locked coherent sampling to translate 1 to 1000 MHz RF signals to 20 kHz IF signals enables accurate detection of voltage magnitude and phase. Automatic phase-locked tuning makes it possible to select the one of 21 overlapping octave ranges which contains the input signal frequency by simply rotating a switch.

Specifications

Frequency range: 1 MHz to 1 GHz in 21 overlapping octave bands; tuning automatic within each band.

Isolation between channels: 1 to 300 MHz, >100 dB; 300 to 1,000 MHz, >80 dB.

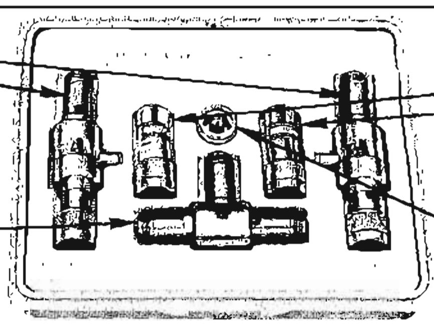
Maximum input: ac, 2 V peak; dc, ±50 V.

Voltage range (rms):

Channel	1 - 10 MHz	10 - 500 MHz	500 - 1000 MHz
A	1.5 mV - 1.0 V	300 μV - 1.0 V	500 μV - 1.0 V
B	<20 μV - 1.0 V	<20 μV - 1.0 V	<20 μV - 1.0 V

11536A 50 Ω Tee, with Type N RF fittings, for monitoring signals in 50 Ω transmission line without terminating the line. $75

908A Termination, for terminating 50 Ω coaxial systems in their characteristic impendence.

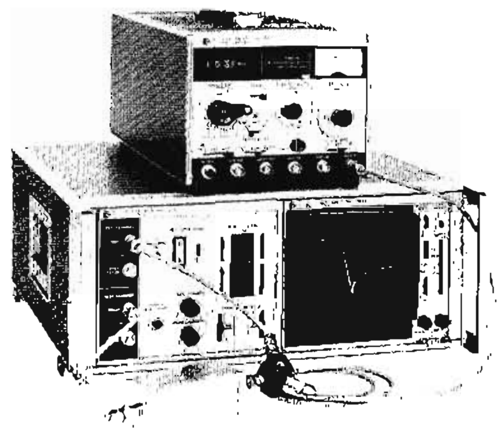


11549A Power Splitter, all connectors Type N female (UG-28A/U). $85

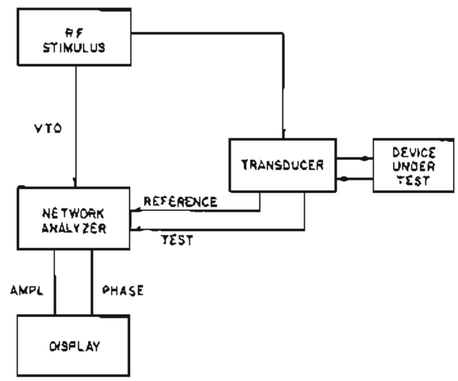
11512A Shorting Plug, Type N male.

11570A Accessory Kit for measurements in 50 Ω systems. $340

RF/NETWORK ANALYZER
Swept complete network characterization
8407 Family



8407 system



8407 block diagram

System Description

The 8407A Network Analyzer System is a versatile measuring system for engineering and testing in the frequency range 100 kHz to 110 MHz; the system is capable of accurate swept measurements of numerous magnitude and phase properties of attenuators, detectors, filters, cables, antennas, recording heads, amplifiers and many other passive and active linear networks.

Measurements include: gain, loss, phase shift (compute group delay), return loss, complex reflection coefficient of networks with 50 or 75-ohm characteristic impedance. Swept complex impedance, |Z|, Θ over the 0.1Ω to >10 kΩ range and swept voltage and current transfer functions, also in-circuit, can be measured with speed and accuracy. The system can also be used for high resolution visual comparison measurements and for making transistor s-parameter measurements with push-button ease. This measurement versatility is achieved through the modular construction of the system.

Basic instruments are: the HP 8601A Generator/Sweeper providing the RF stimulus for the device under test and the VTO output required by the network analyzer; the HP 8407A Network Analyzer which is a ratio meter using both a TEST and a REFERENCE channel input; the HP 8412A Phase-Magnitude display or the 8414A Polar Display for detecting and displaying amplitude and phase as a function of frequency. These instruments have to be combined with the one of six different "transducers" that corresponds to the measurement of network parameters desired.

This modular construction makes the system easily adaptable to new measurement/test requirements—addible at small incremental costs. Thus, system utilization is optimized and obsolescence avoided. Accuracy, speed and flexibility of measurements combine to make the 8407 Network Analyzer System an extremely useful tool for design and development work as well as in production testing.

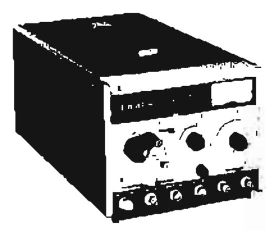
Instrument Description

RF Stimulus

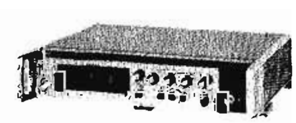
The *HP 8601A Generator/Sweeper* is the signal source that provides the RF stimulus to the device under test and the VTO for the local oscillator of the 8407A Network Analyzers. The 8601A is a 0.1 to 110 MHz CW or swept source. Sweep is in two ranges from 0.1 to 11 MHz and 1 to 110 MHz.

The *HP 8690B/8698B Sweep Oscillator* is the other signal source that can be used with the 8407A Network Analyzer. Sweep is in two ranges from 0.4 to 11 MHz and from 4 to 110 MHz. The 8690B also accepts plug-ins from 100 MHz to 40 GHz.

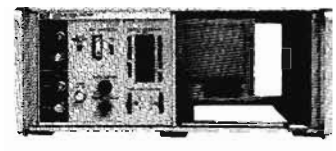
The *HP 8600A Digital Marker* is an optional complement to the 8601A or 8690B/8698B signal sources. The 8600A provides five independent, continuously variable markers which may be placed on a display while making swept measurements. A marker displayed on a counter readout, while sweeping, is useful for very accurately determining frequency values of interest.



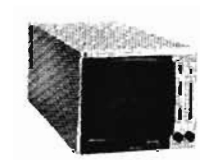
8601A



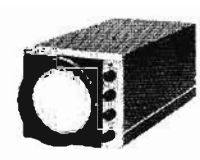
8600A



8407A



8412A



8414A

Network Analyzer

The *8407A Network Analyzer* is a ratio meter using both a TEST and a REFERENCE channel input. The 8407A forms the magnitude ratio and phase difference between these two input signals after their conversion to a constant intermediate frequency. The resultant signals are routed to a display for detection and display. Dynamic range is 80 dB with the 8412A Phase-Magnitude Display, measurement range is from +90 dB to −100 dB. Input power to the device under test can be from −10 dBm to −85 dBm. Display REFERENCE attenuators provide 89 dB of accurate test channel offset permitting high resolution measurements by using IF substitution techniques. Residual magnitude and phase responses versus frequency are typically less than ±0.1 dB and ±2° from 1 to 110 MHz.

Displays

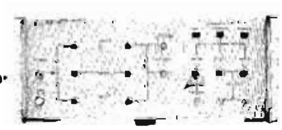
The *8412A Phase-Magnitude Display* is an accurate oscilloscope readout displaying amplitude and phase versus frequency either separately or simultaneously. It has 80 dB and ±180° display range. Measurements with 0.05 dB and 0.2° resolution are possible.

The *8414A Polar Display* has a measurement range of 30 dB and 360°. For reflection measurements, the 8414A displays reflection coefficient as a function of frequency. Smith Chart overlays permit readings of normalized complex impedance values. A rectangular overlay permits readings of R ± jX for impedance measurements over the range 0.1Ω to >10 kΩ.

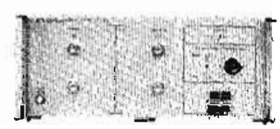
11652A

11654A

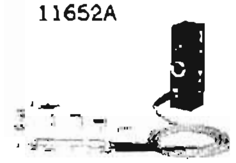
NEW▶



8728B

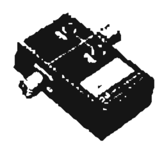


85404B



11655A

1121A



85426A

NEW▶

85428B

Signal conditioners

The *11652A Reflection/Transmission Kit* contains a power splitter and two phase-matched low leakage cables permitting accurate swept measurements of gain, loss and phase shift. It also contains a directional bridge (8721A) with >40 dB directivity, a calibration short and a precision termination for measurements of return loss and reflection coefficient (complex impedance) in 50 or 75-ohm systems.

The *11655A Impedance Probe* makes possible swept accurate complex impedance measurements over the wide impedance range 0.1Ω to >10 kΩ. The 11655A's design allows effective elimination of all reactive parasitics of the probe so that open circuit impedance appears simply as a 10 kΩ resistor. This feature and a built-in 100Ω, 0° calibrator make it possible to measure true values of unknown impedance.

The *11654A Passive Probe Kit* includes two each of probe cables and current probe tips and a wide variety of accessories for grounding and getting at those "difficult to measure" circuits. Voltage or current transfer functions can be measured with a pair of voltage or current probes. By using one voltage probe and one current probe, complex impedance or admittance can accurately be measured at frequencies below 11 MHz.

The *1121A AC Probe* is an active probe biased through the PROBE PWR jacks on the front panel of the 8407A. The probe has a 100 kΩ, 3 pF input impedance. Voltage transfer functions can thus be measured in low level signal circuits with minimum circuit disturbance or in circuits whose characteristic impedance is radically different from 50 ohms.

The *8728B Network Comparator* adds the capability for making swept visual comparison measurements with the 8407A. The transmission characteristics of a test network and of a known standard are traced separately on a highly sensitive large-screen oscilloscope for visual comparison. Level differences of 0.01 dB, 0.2° are easily discernable. The 8728B provides the switching required to accomplish the substitution comparison between the two networks.

The *85404B S-Parameter Test Set* provides all the switching necessary for measuring with push-button ease the four s-parameters of passive and active linear networks with 50 or 75-ohm characteristic impedance (HP 85428B Min Loss Pads for 75-ohm systems). Transistors can easily be measured by using, in conjunction with the test set, the HP 11600B or 11602B Transistor Fixture which plugs into the HP 85426A Bias Insertion Network (2 each required).

Specifications

8407A

Frequency range: 0.1 to 110 MHz.
Measurement range: gain +90 dB, loss −100 dB.
Impedance: 50Ω. Option 008: 75Ω. **VSWR** <1.08.
Amplitude accuracy:
Frequency response (may be calibrated out): ±0.2 dB, 0.1 to 110 MHz; ±0.05 dB over any 10 MHz portion.
Display reference: <0.05 dB/1 dB step, total error <0.1 dB; <0.1 dB/10 dB step, total error <0.25 dB.
Phase accuracy:
Frequency response (may be calibrated out): ±5°, 0.1 to 110 MHz; ±2° over any 10 MHz portion.
Display reference: <0.5°/10 dB step, total error <3°.
Power: 65 watts, 50-60 Hz, 115/230V +10%.
Weight: net, 32 lb (14,6 kg); shipping, 39 lb (17,8 kg).
Dimensions: 7¼″ high, 18⅜″ deep, 16¾″ wide.
Price: 8407A, $2950; Option 008, 75Ω, add $110.

11658A

General: 50 to 75-ohm matching resistor for 8407A.
Insertion loss: 3.5 dB **Return loss:** >40 dB.
Weight: net, 1 oz. **Price:** $30.

8412A

General: plug-in CRT display for 8407A.
Amplitude accuracy: display, 0.08 dB/dB from midscreen.
Phase accuracy:
Display: 0.065°/degree from midscreen.
Phase offset: 0.3°/20 degree step, not to exceed total error of 3° for 360° of change, positive or negative direction.
Vs. displayed amplitude: <1°/10 dB, total error for 80 dB <6°.
Power: 23 watts, supplied by 8407A.
Weight: net, 17 lb (7,8 kg); shipping 22 lb (10 kg).
Price: 8412A, $1,700.

8414A

General: plug-in normalized polar coordinate display for 8407A: magnitude calibration is in 0.2 of full scale gradations, full scale determined by DISPLAY REFERENCE setting on 8407A. Phase calibration is in 10° increments over a 360° range.
Accuracy: all errors in amplitude and phase due to the display are contained within a circle of 3 mm about the measurement point.
Power: 35 watts, supplied by 8407A.
Weight: net, 14 lb (6,4 kg); shipping, 17 lb (7,6 kg).
Price: 8414A, $1,300.

11652A

General: reflection-transmission kit contains power splitter, 8721A directional bridge, a precision 50Ω termination, calibrating short, BNC adapters and matched, low-leakage cables.
Directional bridge: 8721A: 6 dB coupling in main and auxiliary arm. Frequency response is ±0.5 dB, 0.1 to 110 MHz. Directivity is >40 dB, 1 to 110 MHz. Return loss at LOAD port is >30 dB. Price: 8721A, $150; Option 008, 75Ω, add $10.
Power splitter: 6 dB loss through each arm.
50Ω termination: return loss is >43 dB.
Weight: net, 2 lb (0,9 kg); shipping, 3 lb (1,4 kg).
Price: 11652A, $325; Option 008, 75Ω, add $50.

11654A

General: passive probe kit contains a pair each of six resistive divider probes (1:1, 5:1, 10:1, 20:1, 50:1, 100:1) current probes, and variety of adapters.
Weight: *net, 2 lb (0,9 kg); shipping 3 lb (1,4 kg).*
Price: 11654A, $400.

11655A

General: impedance probe, mounts directly onto 8407A. Contains a component mounting adapter, a probe to BNC adapter, a probe to type N adapter and various ground assemblies.
Frequency range: 0.5 to 110 MHz.
Measurement range: amplitude, 0.1Ω to >10 kΩ; phase, 0° ±90°.
Internal calibrator: amplitude 100Ω ±0.5%; phase 0° ±2°.
CW accuracy: amplitude ±5%; phase ±5° for /Z/ >3.16Ω.
Swept frequency accuracy: typically ±5% in amplitude, ±5° in phase from 3-110 MHz; accuracy is decreasing below 3 MHz.
Weight: net, 2lb(0,9kg); shipping, 6 lb (2,7 kg).
Price: 11655A, $750.

1121A

General: 1:1 active probe furnished with 10:1 and 100:1 divider and BNC adapter.
Frequency response: 1 kHz to 100 MHz, ±0.5 dB, ±2°.
Input impedance: 100 kΩ, shunt capacitance 3 pF at 100 MHz; with 10:1 or 100:1 divider, 1 MΩ, shunt capacitance 1 pF at 100 MHz.
Output impedance: 50Ω nominal.
Power: supplied by 8407A through PROBE PWR jacks.
Weight: net, 2 lb (0,9 kg); shipping, 5 lb (2,4 kg).
Dimensions: 3″ high, 8″ deep, 10½″ wide.
Price: $415.

8728B

Frequency range: 0.1 to 110 MHz.
Repeatability: 0.003 dB. **VSWR:** <1.05.
Channel isloation: >90 dB.
Dimensions: 16¾″ wide, 7¼″ high, 18⅜″ deep.
Weight: net, 21 lb 7 oz (9,6 kg); shipping, 27 lb 7 oz (12,3 kg).
Channel tracking: amplitude 0.02 dB, phase ±0.2°.
Price: 8728B, $1,400; Option 006, 75Ω WECO connectors, add $200; Option 008, 75Ω BNC connectors, add $100.

85404B

Frequency range: 0.1 to 110 MHz.
Repeatability: <0.001 dB. **VSWR:** <1.2.
Connectors: 50Ω APC-7; min loss pads (85428B) for 75Ω.
Power: 85 watts, 50-60 Hz, 115/230 V ±10%.
Dimensions: 7″ high, 19⅜″ deep, 16¾″ wide.
Weight: 38 lbs. **Price:** 85404B, $5000.

85426A

General: bias insertion network for 85404B.
Frequency range: 0.1 to 500 MHz.
Insertion loss: <0.4 dB. **Return loss:** >28 dB.
Max bias current: 750 mA, **max bias voltage:** 70 V.
Connectors: BNC for biasing; APC-7 for RF.
Price: 85426A, $300; Option 001 (Female type-N connectors), less $30.

85428B

General: min loss pad (75Ω) for 85404B.
Insertion loss: 5.7 dB. **VSWR:** <1.05.
Price: 85428B (50Ω BNC/m, 75Ω BNC/f), $85; Option 001 (50Ω APC-7, 75Ω GR900), add $175.

MICROWAVE NETWORK ANALYZER

110 MHz to 40 GHz

Model 8410S

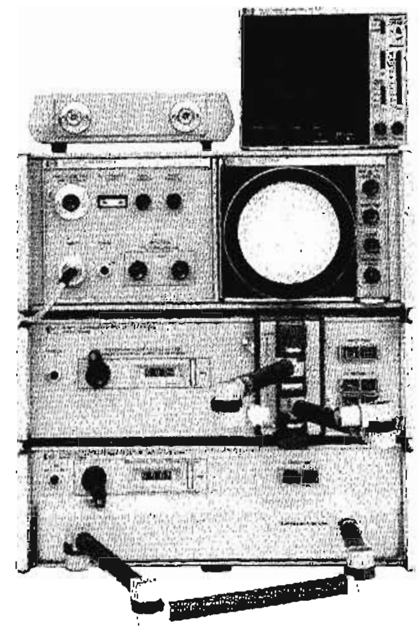
All 8410S Systems measure transmission and reflection parameters of coaxial and waveguide components in the form of gain, attenuation, phase, reflection coefficient or impedance. Each option has been configured either for making general measurements within a frequency range or for push-button S-parameter measurements on semiconductor devices in a variety of package styles. In addition to selected signal conditioner and accessory items, each option contains the 8410 Network Analyzer, 8411A Harmonic Frequency Converter, two plug-in displays (the 8412 Phase Magnitude Display and 8414A Polar Display), and the 11609 Cable Kit. All systems come complete with necessary accessories and interconnecting cables. Overall system accuracy is specified for easier error analysis. Individual instruments which make up the system can also be ordered separately for updating existing network analyzer equipment.

Sweeps over octave bands

Swept displays for efficient real time testing over full-band. Rapid sweep for dynamic CRT display—make adjustments to devices while viewing overall effects.

Wide dynamic range—high resolution

60-dB amplitude and 360° phase displays: use precise offset controls to read amplitude and phase to 0.1 dB and 0.1 degree resolution. No phase ambiguity—meter indicates phase sense directly.



8410S Option 310

8410S Network Analyzer Systems

Frequency range	8410S[1] Option No.	SIGNAL CONDITIONERS 8743A 2-12.4 GHz	8745A/11599A .11-2 GHz	8746B/11608A .5-12.4 GHz	Transistor Bias Supply 8717B	Transistor Fixture 11600B	Transistor Fixture 11602B	Universal Extension 11604A	Flexible Arm 11605A	Accessory Kit 11650A	Price	Use
110 MHz-2 GHz	110*		■					■		■	$13,015	General purpose—low frequency
110 MHz-2 GHz	400		■		■	■					13,170	Characterize semiconductors with TO-18 or TO-72 packages
110 MHz-2 GHz	401		■		■		■				13,170	Characterize semiconductors with TO-5 or TO-12 packages
2-12.4 GHz	210*	■							■	■	12,175	General purpose—high frequency
.5-12.4 GHz	500			■	■						14,670	Characterize stripline semiconductors with TI-Line packages
.5-12.4 GHz	501			■	■						14,670	Characterize stripline semiconductors with K-disk packages
110 MHz-12.4 GHz	310*	■	■					■	■	■	16,490	General purpose—complete frequency coverage

*Options 100, 200, and 300 are identical to 110, 210, and 310 respectively except for the 8412A which is replaced by the 8413A.

[1] The 8410A network analyzer, 8411A harmonic frequency converter, 8412A phase magnitude display, 8414A polar display, and 11609A cable kit are included in each of the above options.

MICROWAVE NETWORK ANALYZER
Swept measurements 0.11-40 GHz
Model 8410S

8410S Specifications

Function: All systems measure transmission and reflection parameters on either a swept-frequency or CW basis in the form of attenuation, gain, phase shift, reflection coefficient, return loss, or impedance depending on readout display.

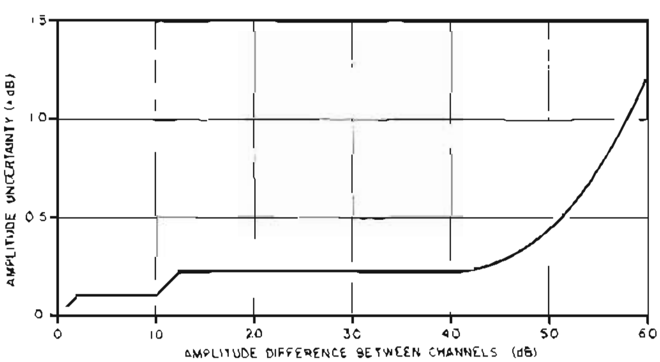
Display units: Choice of 8412A phase magnitude display, 8413 phase-gain indicator, or 8414A polar display. 8412A and 8414A accept intensity marker and blanking signals from Hewlett-Packard sweep oscillators.

Measurement range: full 60 dB dynamic range.

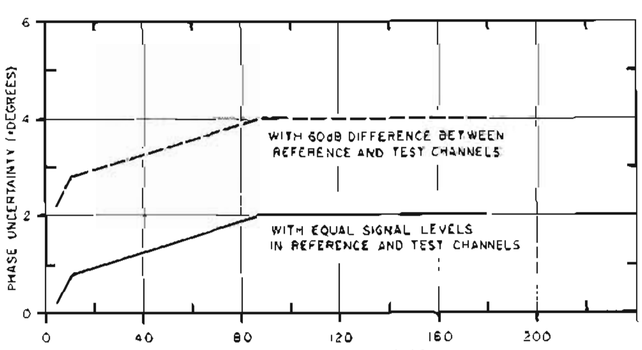
RF input: 20 dB range between −21 dBm and +7 dBm between .11-2 GHz or −14 dBm and +14 dBm between 2-12.4 GHz. 20-dB variation causes less than 1.5 dB and 4° change amplitude and phase readings.

Transmission measurement accuracy: Accuracy curves below show overall system uncertainty when measuring amplitude and phase. Sources of error included are IF gain control, meter accuracy, phase offset, system noise, and crosstalk. System frequency response is specified separately and is not included in accuracy curves.

Transmission amplitude uncertainty.



Transmission phase uncertainty.



Frequency response

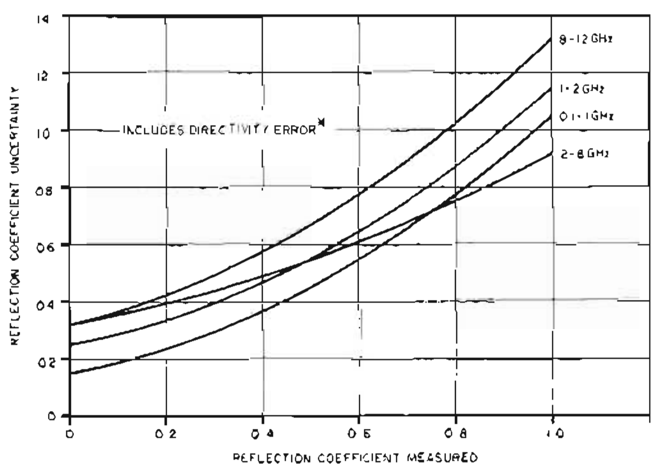
Transmission: typically <+0.35 dB amplitude and <±3° phase for .11 to 2 GHz. <±0.5 dB amplitude and <±5° phase for 2 to 12.4 GHz.

Reflection: magnitude typically <±0.06; phase <±5° .11 to 2 GHz, and <±7° 2 to 12.4 GHz; as read on the 8414A with a short on the unknown port.

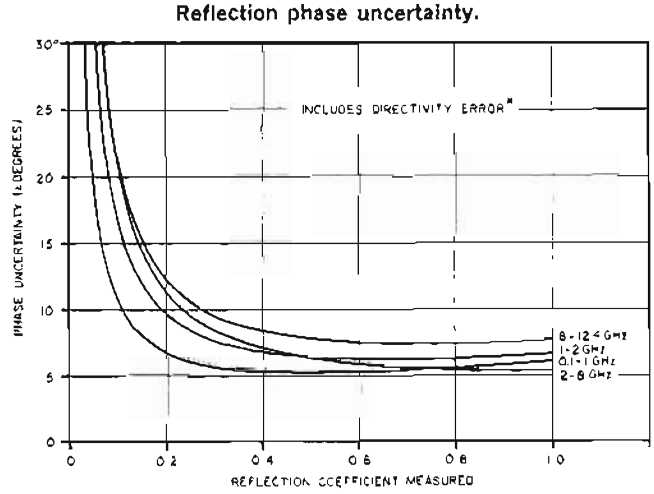
Transmission reflection selection: manual by front panel lighted pushbuttons; remote by contact closure or saturated transistors through 36-pin connector contacts.

Reflection measurement accuracy: Accuracy curves show overall system uncertainty when measuring reflection coefficient. Sources of error included are directivity, source match, and polar display accuracy. System frequency response is specified separately and is not included in the accuracy curves.

Reflection coefficient uncertainty.

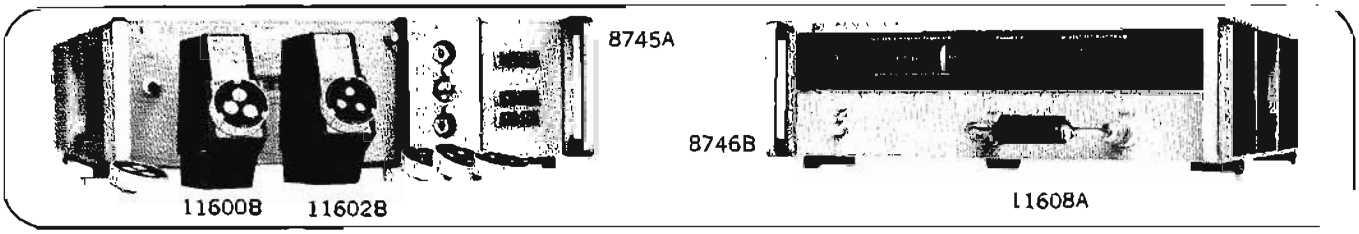


Reflection phase uncertainty.



*Accuracy can be improved by using a sliding load to cancel coupler directivity errors. This will reduce the reflection coefficient uncertainty .015 from .11-1 GHz, .025 from 1-2 GHz, and .032 from 2-12.4 GHz; Phase uncertainty is reduced to a maximum of ±5°.

TRANSISTOR S-PARAMETERS
100 MHz to 12.4 GHz



Transistor S-Parameter Measurements

100 MHz to 2 GHz

The 8745A S-parameter test set combined with the 11600B or 11602B Transistor Fixtures make accurate transistor characterization as easy as pushing a button. Transistors are conveniently biased with the new 8717B Transistor Bias Supply by a simple cable connection to a rear panel connector of the 8745A. The 8745A, 8717B, 11600B and 11602B are capable of making useful S-parameter measurements from 40 MHz to 2 GHz and can be used with either the 8405A Vector Voltmeter, 8407A Network Analyzer, or 8410A Network Analyzer.

Function: used with or without the 8745A to measure transistors and other semiconductor devices. Mounts directly on the 8745A. A calibration short and thru are included with the fixtures.

Model 11600B: for TO-18/TO-72 or similar transistor packages. It has four snap-on dials, two for bipolars and two for FET's.

Model 11602B: for TO-5/TO-12 or similar transistor packages. It has two snap-on dials for bipolars.

Frequency: dc to 2 GHz.

Lead lengths: accepts leads up to 1.5 inches long.

Lead diameters: 0.016 to 0.019 inch.

Impedance: 50Ω ±2Ω.

Connectors: APC-7 precision connectors.

Option 001: precision type N connectors, less $30.

Dimensions: 4⅝" x 6" x 1½" (119 x 152 x 38 mm).

Weight: net, 4 lb (1,8 kg); shipping, 5 lb (2,3 kg).

Price: 11600B, $600; 11602B, $600.

500 MHz to 12.4 GHz

The 8746B S-parameter Test Set combined with the 11608A Transistor Fixture permit complete characterization of TO-51 and K-disc packaged stripline transistors. The 8717B Transistor Bias Supply conveniently attaches to the 8746B Bias Networks with a rear panel connector cable. With the 8717B it is possible to make frequency swept measurements of all four S-parameters as a function of load current and voltage with pushbutton ease. The 8746B, 11608A, and 8717B can be used with either the 8405A Vector Voltmeter or 8410 Network Analyzer.

Function: used with the 8746B for completely characterizing stripline transistors. Mounts directly on 8746B. A calibration short and a thru are included with Options 002 and 003.

Frequency range: DC to 12.4 GHz.

VSWR: (measured with thru-line calibration unit inserted and one end of the fixture terminated in a 50-ohm load).
<1.10 to 4 GHz.
<1.15, 4 GHz to 8 GHz.
<1.25, 8 GHz to 12.4 GHz.

Striplines: 0.031" thick (P.P.O.); 0.080" wide.

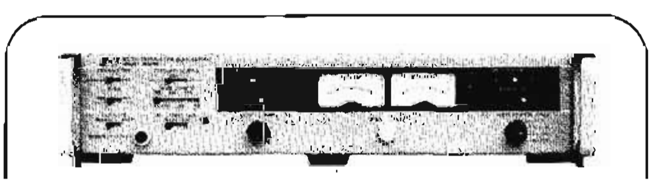
Impedance: 50Ω.

Dimensions: 5⅝" x 3½" x 1" (143 x 89 x 25 mm).

Weight: net, 2 lb (0,9 kg); shipping, 3 lb (1,4 kg).

Option 001: machinable for custom packages, $375.
Option 002: TO-51 (0.250 inch diameter), $400.
Option 003: HPAC-200 (0.205 inch diameter), $400
Opt. 100: type N (female) connectors, less $30.

8717B Transistor Bias Supply



8717B

The 8717B Transistor Bias Supply is an ideal power supply for manual or programmable transistor testing. It is particularly useful with the 11600B, 11602B, and 11608A Transistor Fixtures. The 8717B has two meters for independently monitoring current and voltage on any of the three leads of a transistor under test. Bias connections are conveniently selected for all transistor configurations (EBC, BEC, BCE) with a front panel switch. Special circuitry protects sensitive (expensive) devices from excessive current transients which commonly occur in less sophisticated supplies during accidental loss of line power or when applying or removing bias.

Specifications, 8717B

Voltage ranges: 1, 3, 10, 30, 100 V.

Current ranges: 0.1, 0.3, 1, 3, 10, 30, 100, 300, 1000 mA.

Accuracy: 4% of meter full scale for both current and voltage.

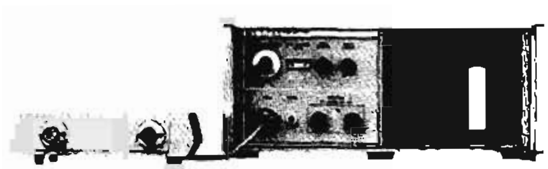
Dimensions: 16¾" x 3⅜" x 13½" (425 x 86 x 336 mm).

Weight: net, 20 lbs (9,0 kg); shipping, 25 lbs (11,0 kg).

Price: 8717B, $1800.

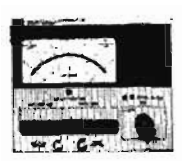
Option 001: programmable D/A converter, $650.

MICROWAVE NETWORK ANALYZERS
Individual instruments
8410 Family



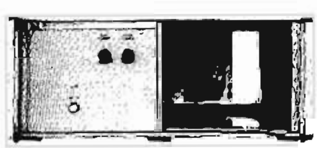
8411A 8410A

8412A



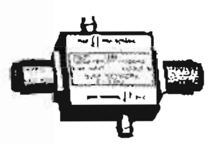
8413A

8414A



8418A

11587A



11589A

Network analyzer

8410A Network Analyzer, 8411A Frequency Converter

Function: 8411A Harmonic Frequency Converter converts RF signals to IF signals for processing in 8410A Mainframe. 8410A is the mainframe for display plug-in units. Mainframe includes tuning circuits, IF amplifiers, and precision IF attenuator.

Price: Model 8410A, $2200; Option 005 (compatible with 8418A), add $100; Model 8411A, $2600.

Display units

8412A Phase-Magnitude Display

Function: plug-in CRT display unit for 8410A or 8407A. Displays relative amplitude in dB and/or relative phase in degrees between reference and test channel inputs versus frequency.

Price: Model 8412A, $1700.

8413A Phase-Gain Indicator

Function: plug-in meter display unit for 8410A or 8407A. Displays relative amplitude in dB between reference and test channel inputs or relative phase in degrees. Pushbutton selection of meter function and range.

Price: Model 8413A, $1300.

8414A Polar Display

Function: plug-in CRT display unit for 8410A or 8407A. Displays amplitude and phase data in polar coordinates on 5" cathode ray tube.

Price: Model 8414A, $1300.

8418A Auxiliary Power Supply

Function: provides power for operation of the 8412A Phase-Magnitude Display, the 8413A Phase-Gain Indicator or the 8414A Polar Display Unit. Used in conjunction with the Option 005 8410A Network Analyzer, it provides the capability of viewing amplitude and phase readout in both rectangular and polar coordinates simultaneously.

Price: Model 8418A, $800.

Accessories

11587A, 11650A Accessory Kits

Function: 11650A contains accessories normally used for transmission and reflection tests with the 8745A and 8743A. 11587A contains accessories normally used for transmission and reflection measurements with the 8740A, 8741A and 8742A.

Weight: net, 4 lbs (1.34 kg); shipping, 5 lbs (2.2 kg).

Price: 11587A, $1005; 11650A, $805

11589A and 11590A Bias Networks

Function: provides dc bias and bias sensing on 50Ω systems.

Frequency range: 11589A; .10-3 GHz. 11590A; 1-12.4 GHz.

VSWR: <1.2.

Insertion loss: <0.8 dB.

Connectors: Type N.

Price: Models 11589A, $275; or 11590A, $325.

Option 001: APC-7 connectors, add $30

Signal conditioners

8740A Transmission Test Unit

Function: RF power splitter and calibrated line stretcher for transmission measurement with network analyzer.
Frequency range: dc-12.4 GHz.
Price: Model 8740A, $1600.

8741A and 8742A Reflection Test Units

Function: wideband reflectometer, phase-balanced for swept or single frequency impedance tests with 8410A. Calibrated adjustable reference plane.
Frequency range: 0.11-2.0 GHz (8741A); 2.0-12.4 GHz (8742A).
Price: Model 8741A, $1700; Model 8742A, $1800.

8745A S-Parameter Test Set

Function: wideband RF power splitter and reflectometer with calibrated line stretcher. Pushbutton operated for either transmission or reflection measurements with network analyzer.
Frequency range: 0.1-2 GHz.
Price: Model 8745A, $3300; Option 001 (type N female connectors on outputs to 8411A), no additional charge.

11599A Quick Connect Adapter

Function: quickly connects and disconnects the 8745A and the transistor fixtures or 11604A Universal Extension.
Dimensions: 3" x 5" x 4¼" (76 x 127 x 108 mm).
Weight: net, 14 oz (397 gm); shipping, 2 lbs (652 gm).
Price: Model 11599A, $90.

11604A Universal Extension

Function: mounts on front of 8745A; connects to device under test. Rotary air lines and rotary joints connect to any two-port geometry.
Weight: net, 4 lbs (1,9 kg); shipping, 6 lbs (2,5 kg).
Dimensions: 10½" x 5" x 1¼" (267 x 127 x 31,6 mm).
Price: Model 11604A, $925

11607A Small Signal Adapter

Function: used with the Hewlett-Packard Model 8745A S-Parameter Test Set. It permits measurements with Model 8410A Network Analyzer with incident signal levels to the test device in the −20 to −40 dBm range.
Frequency range: 0.11-2.0 GHz.
Price: $600

8743A Reflection/Transmission Test Units

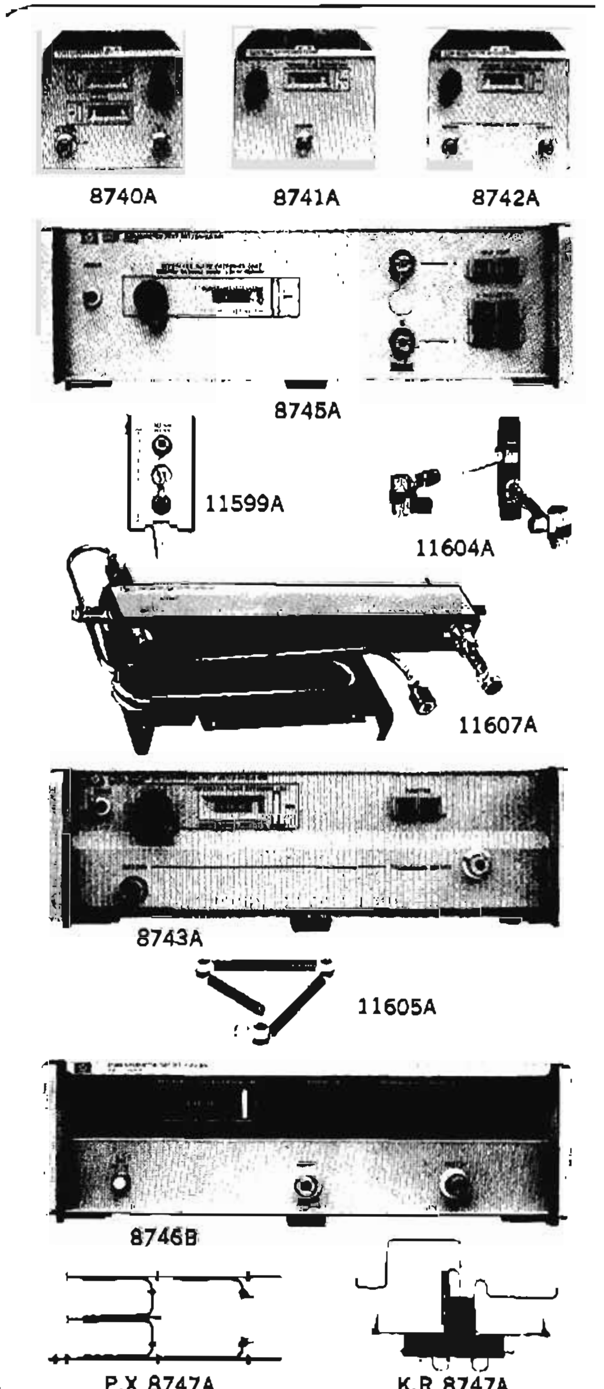
Function: wideband RF power splitter and reflectometer with calibrated line stretcher. Pushbutton operated for either transmission or reflection measurements with network analyzer.
Frequency range: 2-12.4 GHz.
Price: Model 8743A, $2675.

11605A Flexible Arm

Function: mounts on front of 8743A; connects to device under test. Rotary air lines and rotary joints connect any two-port geometry.
Weight: net, 4 lbs (1,8 kg); shipping, 6 lbs (2,7 kg).
Length: 10.1" (256,3 mm) closed, 25.5" (647,7 mm) extended.
Price: Model 11605A, $800

8746B S-Parameter Test Set

Function: wideband RF power divider and reflectometer with calibrated line stretcher and a selectable 0-70 dB incident signal attenuator. Pushbutton operated for either transmission or reflection measurements with network analyzer.
Frequency range: 0.5 to 12.4 GHz.
Price: $5000.



P,X 8747A Reflection/Transmission Test Units

Function: waveguide setup for measuring reflection and transmission parameters of waveguide devices with the network analyzer.
Frequency range: X8747A: 8.2-12.4 GHz; P8747A: 12.4-18 GHz.
Price: Model X8747A, $1950; P8747A, $1950.

K,R 8747A Reflection/Transmission Test Units

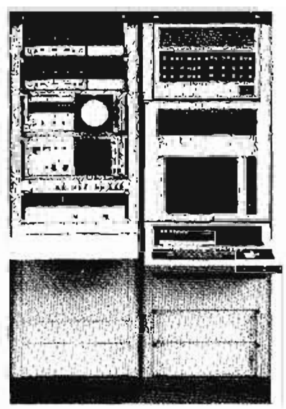
Function: waveguide setup for measuring reflection and transmission parameters of waveguide devices with the network analyzer; down-converts with built-in mixers to the frequency range of the 8411A.
Frequency range: K8747A: 18-26.5 GHz; R8747A: 26.5-40 GHz.
Price: Model K8747A, $5650; R8747A, $6300

AUTOMATIC NETWORK ANALYZER
Speed, accuracy, and ease of operation
8540 Series

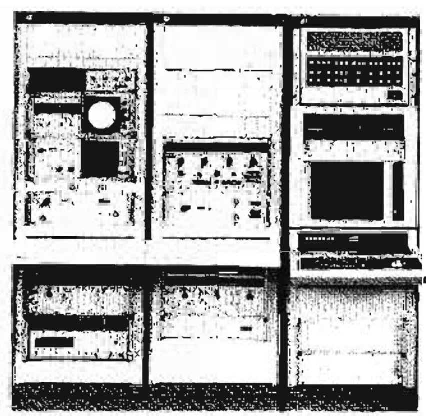
An 8540 series system couples the network analyzer's ability to measure the linear characteristics of a device with a computer's ability to completely set-up a measurement, store data and solve complex mathematics. As a result the system can greatly improve the measurement accuracy, speed, and ease of operation. It can format the data in the most useful manner by computing a variety of parameters and outputting in alphanumerical or graphical form on either hardcopy, cathode-ray tube or cassette. It is supplied with a complete set of programs which virtually remove the need for programming. The system is currently in use in over 100 different facilities covering the range of production, design, calibration and metrology applications.

The 8545A can be operated stand-alone or under the control of a timeshare system. The timeshare system is accessed either by dial-up telephone lines or by a hardwire connection to a resident timeshare system. A minimum configuration stored-program computer provides the local intelligence to program the measurement and to return uncorrected data to the operating program resident in the timeshare system. This configuration is advantageous because it provides 1) a lower cost entry into the field of automatic microwave measurement and 2) the easily accessed computing and storage capability of the timesharing system. The dedicated 8545A and the 8542B both operate under the exclusive control of a local stored program computer. This configuration is advantageous because of 1) the turnkey nature of its versatile package of application programs 2) its lower operating costs and its greater throughput. The 8542B provides the best accuracy as well as the widest frequency coverage.

8545A
Timeshared



8545A
Dedicated operation



8542B
Dedicated operation

Summary of characteristics

Frequency range: for the timeshared and dedicated 8545A the frequency range is 110 MHz* to 12.4 GHz. For the 8542B the frequency range is 100 MHz to 12.4 GHz (18 GHz optional).

Accuracy: low level reflection can be performed with 0.015 accuracy and transmission measurements can be performed with 0.20 dB accuracy on the timeshared and dedicated 8545A. These same measurements can be performed with 0.003 and 0.05 dB accuracy on the more precise 8542B.

Speed: for the timeshared 8545A, speed varies according to the data communication speed. For the dedicated 8545A and 8542B, 20 measurements can be performed in one second with full automatic error correction. This represents a conservative 5-20 times throughput improvement over the less accurate equivalent manual measurement, depending on the device tested.

Software: for the timeshared 8545A, easy interface to timesharing system software with measure command. For the dedicated 8545A and 8542B virtually no programming is required by the user thanks to a complete, versatile series of application programs. These programs can be used by simply filling a measurement program form. ATS BASIC is made available for special testing occasions.

Price: Timeshared 8545A from $40,000, Dedicated 8545A from $67,300, and the 8542B from $139,500 (.1-12.4 GHz).

*The 8543A provides frequency coverage from 100 kHz to 110 MHz with extremely high accuracy (.002 reflection, .02 dB transmission) and the same advantages of speed, flexibility and ease of operation characteristic of the 8540 series.

Meeting the requirements of the communications industry is a rapidly expanding activity of Hewlett-Packard. The instruments described in this section were designed to meet these requirements and many of their capabilities were established by close cooperation with the industry.

Balanced/symmetrical measurements

The world of telecommunications is characterized by the extensive use of balanced or symmetrical circuitry. The basic reasoning behind this is that the extremely large number of circuits in close physical proximity to each other and to 50/60 Hz power lines must have some protection against pickup of spurious and unwanted signals. Shielding is usually not practical, since most of the coupling is electromagnetic due to the relatively low impedance of the circuits. This kind of coupling requires expensive magnetic shielding to be effective. The solution, then, is to operate the circuits balanced or symmetrical. Provided the two sides of the circuit receive relatively equal exposure to the source of interference, the coupling will be in the form of a longitudinal or common-mode voltage: i.e., equal amplitude and phase on both sides of the circuit. The balanced input of various amplifiers in the telephone multiplex equipment will ignore spurious signals by virtue of their common-mode rejection capability.

DB readings are typically used in the communications industry rather than voltage readings as power is generally of more interest. DB readings compress the extremely wide range of voltages and powers in a communications system and offer the ability to compute gain and loss.

Hewlett-Packard dedicated communications instruments properly indicate dB, dBm or dBrn regardless of the input impedance chosen. Wide frequency ranges allow measurements to be made on voice frequency circuits or carrier systems up to 3600 channels. Narrow bandwidth filters are available to make highly selective measurements in voice frequency telegraph systems using frequency shift keying techniques. Wider bandwidths are available to allow a complete 3.1 kHz voice channel to be measured. Sweep and wide dynamic range plotting capability makes possible highly accurate measurements of group filters, channel bank filters and voice frequency telegraph filters. Hewlett-Packard selective voltmeters and tracking detectors may be used as a team to allow the entire baseband spectrum, or a portion thereof, of a carrier system to be displayed on an oscilloscope. They may be used to determine the frequency response of active or passive transmission devices. Hewlett-Packard selective voltmeters make highly accurate and wide range measurements practical in most complex communications systems.

High quality long-haul communications would be impossible if it were not for the telephone carrier system. A carrier system combines a large number of communications channels having a normal 4 kHz bandwidth into a single baseband, which may be many MHz in bandwidth and which can be used to modulate a microwave radio system or transmitted direct over a coaxial cable system. Each voice channel is given a definite frequency assignment and by modulation techniques (usually single sideband suppressed carrier) elevated to an assigned slot. An individual channel may occupy a different frequency slot from those shown at different stages in a carrier system, but the channel will still be a nominal 4 kHz wide. In order to synchronize the receive demodulators with the send modulators (since the carrier is suppressed) and to provide level regulation, several pilot tones are inserted in spaces between channels. Hence, a carrier system produces a signal having a very complex spectrum. Since this baseband signal represents the capability of transmitting 3600 revenue-producing toll circuits, down time is out of the question and maintenance must be performed on an "in-service" basis. This is where the selective voltmeter finds one of its most practical applications. It can be used to examine the entire baseband, signal by signal, without interfering with or interference from the other signals.

Noise measurements

The theory of message-circuit noise measurement is based on a relative interfering effect of the noise on the subscriber's hearing. Because of the frequency response of the telephone subset and the fact that the human ear responds differently to noise of various frequencies, a weighting function is assigned to each frequency in proportion to its contribution to the interfering effect. The weighting curve currently accepted as a U.S. Standard is the Bell System C-message weighting. The unit used to define noise measured in this manner is dBRNC, meaning deciBels above Reference Noise, C-message weighted. The CCITT recommendation is psophometric weighting, which as a slightly different curve and is referenced to 800 Hz. The measuring units for this weighting are picowatts psophometric, pWp.

Selective voltmeters

The low noise and wide dynamic range of Hewlett-Packard selective voltmeters make them useful for many telephone applications including measurement of system flatness, analysis of distortion and intermodulation (crosstalk) in carrier systems, and measurement of noise levels. Input impedances of 50, 60, 75, 124, 135, 150 ohms or bridging, balanced or unbalanced are selectable at the front panel of HP's Model 312A.

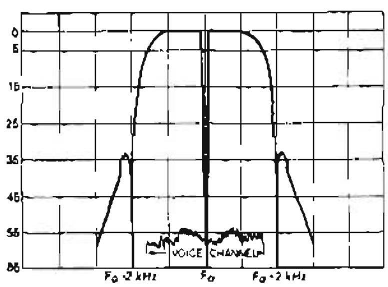


Figure 1. Bandpass for the 312A Opt. 001 Selective Voltmeter.

The HP 312A Option 001 provides carrier system operators with a filter that allows channel noise measurements with a 3 kHz bandwidth. Two notches are superimposed 2 kHz away from the center frequency. Better carrier rejection is obtained, as can be seen in Figure 1. If the carrier frequency is known, the HP 312A Option 001 need only be tuned to 2 kHz above or below the carrier frequency, and the carrier frequencies adjacent to the voice channel are attenuated 45 dB before they are detected.

The indication is a much truer representation of channel noise.

Impedance levels

Generally, in the United States, subscriber's loops are of nominal 900 ohm impedance. 600 ohms is an accepted trunk and tollboard impedance and is found in the many miles of open-wire carrier still in use. The CCITT does not recognize 900 ohms as a subscriber-loop impedance but recommends 600 ohms.

GENERAL INFORMATION

Wire-cable carrier, typically short-haul, uses 135-ohm cable. Many higher capacity systems use 135 ohms as an interface impedance on a group or supergroup basis. The CCITT equivalent of this impedance is 150 ohms. Long-haul coaxial-cable carrier systems use 75 ohms in the United States and in the CCITT recommended systems.

Measure amplitude, phase and group delay

The HP 3040A, 3041A and 3042A Network Analyzers make transmission gain, phase and group delay measurements on linear telecommunications devices. Both point-by-point and swept measurements can be made.

Designed primarily for the telecommunications manufacturer and lab, these transmission test sets make gain measurements with 0.01 dB resolution, phase measurements with 0.01° resolution and delay measurements with 20 choices of "split frequency" and with as much as one nanosecond sensitivity. A digital offset feature allows any test to be referred to a previous reading so differential gain and delay can be measured easily.

3040A Transmission Test Set

The 3040A consists of a frequency synthesizer as the transmitter and a two-channel, selective, tracking receiver. All measurements are made at precise frequencies since the transmitter is a stable and accurate frequency standard. The 3040 can also characterize narrow band devices with extremely high Q. The 3040A can be operated either manually or remotely. All front panel switches are programmable using the new HP ASCII BUS, which offers the advantages of easy software and interfacing. ASCII is the code used by teletypes and many other popular I/O devices.

3041A Semiautomatic TTS

The 3041A adds a 3260A marked card programmer to the basic test set. The card programmer gives the 3041A the ability to do limit testing on gain, phase or delay measurements. The HI-GO-LO testing is useful in production since it simplifies the operator's task and reduces errors.

When doing point-by-point limit tests, front panel annunciators give the HI-GO-LO indication. Swept limit testing can be done in one of two ways:

1. Limit sweep stop—the 3041A stops sweeping when a limit point is crossed (restart sweep by depressing LIMIT SWEEP RESTART button).
2. Limit sweep no-stop—the 3041A does not stop but does intensify limit point on a CRT display.

3042A Automatic TTS

The 3042A adds an HP Model 20 Calculator to the basic test set.

The 3042A is an ideal manufacturing and research tool since it can be operated manually or programmed quickly for different tasks using magnetic cards. Complete tests for filters, equalizers and other telecommunications devices can be run without operator assistance and the results evaluated by the calculator.

For more information on the 3040A, 3041A and 3042A, see catalog pages 407-412.

Microwave radio links

In most countries, the main communications system consists of a network of FM Microwave Radio Links. These links can typically carry up to 1800 telephony channels and use either a 4 GHz or 6 GHz RF band.

The common objective for all types of traffic carried by these links, whether it be telephony, television or low speed data, is to convey the information with the minimum amount of distortion. Failure to keep the distortion within acceptable limits not only results in an unusable signal, but also incurs a severe financial penalty due to lost revenue. Fortunately, the major causes of distortion can be identified and, in many cases, with the availability of suitable test equipment, can be minimized to acceptable levels.

The major contributors to distortion in FM links are the baseband and IF sections, of which modulators, demodulators, IF amplifiers and filters are examples. Also technological development has lead to more signal processing at RF, necessitating distortion measurements in the RF bands.

Differential Phase, Differential Gain and Group Delay Distortion are the main parameters that require monitoring. Users of microwave radio links regularly measure these parameters to ensure optimum performance in the frequency domains of baseband, IF and RF. In many cases, the measurements can be made against reference information supplied by the link manufacturer.

The instruments under the title MICROWAVE LINK ANALYSIS in this section were developed specifically for the purpose of measuring various forms of distortion on microwave radio links and their measurement capabilities were established by close cooperation with the industry.

Digital transmission measurements

As a result of transmission through a dispersive medium, all signals experience distortion. A major advantage of transmitting information in a digital form is that digital signals can be reconstructed from signals which have been distorted, a process called regeneration. Errors occur in regenerators and elsewhere in a digital transmission system and the criterion used in assessing the performance of a system is Bit Error Rate (BER); a measure of the number of received bits in error for a given number of transmitted bits. BER is measured by stimulating the system under test with a pseudo-random binary sequence and then comparing the system output, bit by bit, with an independent reference sequence so that all errors can be detected.

The Hewlett-Packard Bit Error Measuring System (Data Generator and Error Detector) measured BER from 1.5 to 150 M bits/second. The Data Generator also supplies many of the test sequence required for the development and evaluation of digital transmission systems. For example, it will stimulate sequences with long blocks of zeros to check the timing recovery circuits used in regenerators for binary Pulse Code Modulation communications systems.

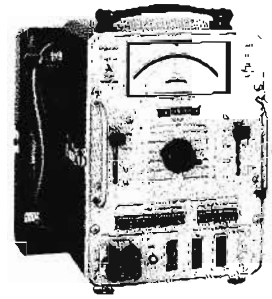
Many Hewlett-Packard instruments listed in this catalog meet many requirements of the telecommunications industry. For example, HP's 3403B AC Voltmeter (see Page 75) has a dB display which provides readings directly in dB which is a major convenience to ac users. The dB reference to which the measurement is made, is conveniently adjustable from the front panel both to provide a convenient means to offset the reading by as much as 13 dB for unreferenced measurements.

For your general purpose instruments needs, see Pages 311-325 (oscillators and function generators) and Pages 42-102 (analog and digital voltmeters).

TRANSMISSION & NOISE MEASURING SET
Psophometer
Model 3555B/3556A

COMMUNICATIONS TEST EQUIPMENT


3555B


3556A

The HP 3555B Transmission & Noise Measuring Set and HP Psophometer are designed especially for telephone plant maintenance. Both instruments measure transmission gain, loss, cross-talk coupling and noise. The weighting curves of the 3555B complies with the Bell System C-message weighting standard. Besides the built-in C-message, program, 3 kHz and 15 kHz filters are also included.

The 3556A has built-in telephone program filters weighted according to 1960 CCITT recommendations. Also included are 3 kHz and 15 kHz filters. Operating instructions printed in the protective cover are available in different languages at no extra charge. Refer to data sheet.

Complementary equipment for the 3555B is the HP 236A Telephone Test Oscillator (236A Opt. H10 for the 3556A). When used together, they make a complete transmission test set for accurate, convenient voice and carrier measurements.

Specifications*

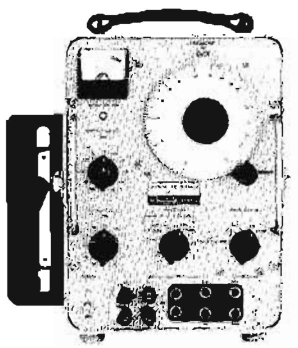
	3555B (Bell Standards)	3556A (CCITT STANDARDS)
VOICE FREQUENCY LEVEL MEASUREMENTS: 20 Hz to 20 kHz		
db/volt range	−91 dBm to +31 dBm	−78 dBm to +32 dBm/0.1mV to 30 V F.S.
Level accuracy**	±0.5 dB; ±0.2 dB, 40 Hz to 15 kHz, level >60 dBm	100 Hz to 5 kHz: ±0.2 dB; 20 Hz to 20 kHz: ±0.5 dB
Input	Terminated or bridged 600Ω or 900Ω balanced. Bridging loss: <0.3 dB at 1 kHz. Balance: >80 dB at 60 Hz, >70 dB at 6 kHz, >60 dB to 20 kHz. Return loss: 30 dB min (50 Hz to 20 kHz)	Terminated: 600Ω symmetrical. Nonterminated: 10 kΩ symmetrical. Nonterminated error: <0.4 dB at 800 Hz. Symmetry: >80 dB at 50 Hz, >70 dB at 6 kHz, >50 dB to 20 kHz. Return loss: 30 dB min (50 Hz to 20 kHz)
Holding circuit	700Ω dc resistance, 60 mA max. loop line current at 300 Hz. With holding circuit in, above specs apply from 300 Hz to 4 kHz	
NOISE MEASUREMENTS:		
dB/volt range	−1 dBrn to +121 dBrn	−78 dBm to +32 dBm/0.1 mV to 30 V F.S.
Weighting filters	3 kHz, 15 kHz, C-message, and program. (EEI, Bell System)	3 kHz, 15 kHz, telephone and program. (P53, CCITT)
Input	Same as for voice frequency measurements	
CARRIER FREQUENCY LEVEL MEASUREMENTS:		
dB/volt range	−61 dBm to +11 dBm	−48 dBm to +12 dBm/3 mV to 3 V F.S.
Level accuracy	600Ω balanced (symmetrical): 1 kHz to 150 kHz, ±0.5 dB; 10 kHz to 100 kHz, ±0.2 dB. 135Ω balanced (or 150Ω balanced)†: 1 kHz to 600 kHz, ±0.5 dB; 10 kHz to 300 kHz, ±0.2 dB. 75Ω unbalanced (asymmetrical): 100 Hz to 600 kHz, ±0.2 dB; 30 Hz to 1 MHz, ±0.5 dB; 1 MHz to 3 MHz, ±0.5 dB ±10% of meter reading	
Input	Terminated or bridged 135Ω† or 600Ω balanced (symmetrical) and 75Ω unbalanced (asymmetrical)	
Return loss	600Ω: 26 dB min., 3 kHz to 150 kHz; 135Ω†: 26 dB min. 1 kHz to 600 kHz; 75Ω: 30 dB min. to 3 MHz	
Bal/symmetry	>70 dB to 10 kHz, >60 dB to 100 kHz, >40 dB to 600 kHz	
GENERAL:		
Meter	Linear dB scale	Linear dBm scale
External battery	24 V or 48 V office battery, <15 mA	
Internal battery	Single NEDA 202, 45 V "B" battery. Option H03 uses rechargeable batteries and similar to 3556A	4 rechargeable batteries (25 V total) or power line from 90 V to 250 V ac, 48 Hz to 440 Hz, <10 VA. Option 001 uses same battery as 3555B
AC:	115 or 230 V (specify for 3555B) (switch for 3556A) 48 Hz to 440 Hz, <10 VA	
Dimensions	7¾ in. wide x 11¾ in. high x 8⅛ in. deep	197 mm wide, 299 mm high, 207 mm deep
Weight	Net: 15 lb (6.8 kg) shipping: 17 lb (7.5 kg)	
Jacks	Will accept Western Electric 241, 309, 310, 358, 289 and 347 plugs; 1011B hand-set or 52 typo head-set	Will accept Siemens 9 REL KL1-6A, 4 mm diameter banana plugs or 3-prong Siemens 9 REL STP-6AC connector
Price	HP 3555B $695	HP 3556A $800

*Refer to data sheet for specifications.
**For levels >1 dBm accuracy spec applies only for freq. above 100 Hz.
†150Ω for 3556A.

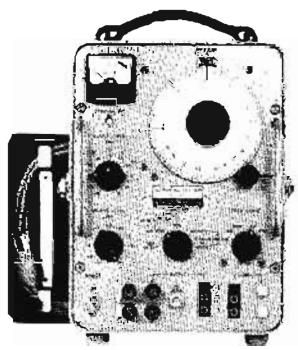
TELEPHONE OSCILLATOR

Complete TMS with 3555B or 3556A

Model 236A and Options



236A Opt H10



236A

General

The solid-state Hewlett-Packard 236A and 236A Option H10/H20 Telephone Test Oscillators are designed specifically to deliver transmission test signals. They are particularly useful for lineup and maintenance of telephone voice and carrier systems.

Description

The HP 236A is the perfect companion to the HP 3555B Transmission/Noise Measuring Set for accurate, convenient voice and carrier measurements meeting Bell standards. Likewise, CCITT recommendations are met when the HP 236A Option H10 and HP 3556A Psophometer are used together. Refer to page 429 for specifications and details.

Complementary equipment for the 236A is the HP 3555B Transmission and Noise Measuring Set (3556A Psophometer for the 236A Option H10). When used together, they make a complete transmission test set for accurate, convenient voice, carrier and noise measurements. Operating instructions printed in the protective cover are available in different languages (236A Option H10 and H20 only) at no extra charge. Refer to data sheet.

Specifications*

	236A (Bell)	236A Option H10 (CCITT)
Frequency range	50 Hz to 560 kHz	
Frequency dial accuracy	±3% of setting	
Frequency response		
600Ω output	±0.3 dB from 50 Hz to 20 kHz	
900Ω output	±0.3 dB from 50 Hz to 20 kHz	
135Ω output	±0.3 dB from 5 kHz to 560 kHz	
150 and 75Ω outputs		±0.3 dB from 5 kHz to 560 kHz
Output level/accuracy	−31 to +10 dBm in 0.1 dBm step/±0.2 dBm from −31 to +10 dBm (1 kHz ref., Opt. H10, 800 Hz ref.)	
Noise	At least 65 dB below total output or −90 dBm - whichever noise is greater	
Distortion	At least 40 dB below fundamental output	
Output circuit	Balanced (symmetrical) and floating. Can be operated up to ±500 V dc above (earth) ground	
Output impedance	600 and 900Ω ±5% 135Ω ±10%	600 and 150Ω symmetrical 75Ω asymmetrical
Output balance (output symmetry)	600 and 900Ω outputs: 70 dB at 100 Hz, 55 dB at 3 kHz 135 and 150Ω outputs: 50 dB at 5 kHz, 30 dB at 560 kHz	
Output jacks	Accepts Western Electric 241, 309, and 310 plugs	Accepts 3-prong Siemens 9 REL, STP 6 AC or 4mm diamenter banana plugs
	Binding posts accept banana plugs, spade lugs, phone tips or bare wires. Removable shorting bar between sleeve and ground binding posts.	
Dial jacks	Accepts Western Electric 309 and 310 plugs. Clip posts accept Western Electric 1011B lineman's hand-set clips	Accepts 3-prong Siemens 9 REL, STP 6 AC or 4mm diameter plugs. Clip posts accept lineman's handset clips as alligator clips
DC holding coil	600 and 900Ω outputs only. 700Ω ±10% dc resistance; 60 mA maximum loop current at 100 Hz	
Power requirements	Line: 115 or 230 V (switch) ±10% ac, 48 Hz to 440 Hz, <2 VA Internal battery: single NEDA 202 45 V "B" battery 236A Option H20: (same as 236A Option H10 except) five 6.25 V rechargeable batteries; 90 V - 250 V ac, 48 Hz - 440 Hz, <10 VA during battery charge	
Weight	Net: 13.5 lbs (6,1 kg); shipping 17 lbs (7,7 kg)	
Complementary equipment	HP 3555B Transmission and Noise Measuring Set. See page 429	HP 3556A Psophometer. See page 429
Price	HP 236A, $630	HP 236A Option H10 (ac line and dry battery), $735 HP 236A Option H20 (ac line and rechargeable batteries),

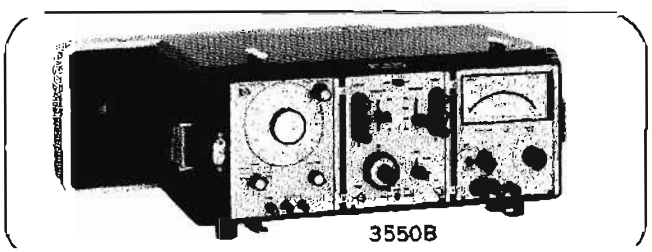
* Refer to data sheet for complete specifications.

PORTABLE TEST SET

Measures transmission line characteristics

Model 3550B

COMMUNICATIONS TEST EQUIPMENT



3550B

Description

The Hewlett-Packard Model 3550B Portable Test Set is designed specifically to measure transmission line and system characteristics such as attenuation, frequency response, or gain. It is particularly useful for lineup and maintenance of multichannel communication systems. Model 3550B contains a wide range oscillator, a voltmeter, and a patch panel to match both the oscillator and the voltmeter to 135, 600, and 900 ohm lines. These instruments are mounted in a combining case that is equipped with a splash-proof cover. In addition, the oscillator, voltmeter, and patch panel may be used separately whether they are in or removed from the combining case.

Both the oscillator and voltmeter are transistorized and operate from their internal rechargeable batteries or from the ac line. The batteries provide 40 hours of operation between charges and are recharged automatically during operation from the ac line.

Specifications*

Oscillator 204C Opt. H20

Frequency range: 5 Hz to 1.2 MHz in 6 ranges. Vernier.

Dial accuracy: ±3% of setting.

Frequency response: +5% −1% 5 Hz to 100 Hz. ±0.5% 100 Hz to 300 kHz. ±1% 300 kHz to 1.2 MHz (normal).

Output impedance: 600Ω.

Output: >2.5 V rms (10 mW or +10 dBm) into 600Ω; >5 V rms open circuit. Can be floated up to ±500 V peak between output and chassis ground.

Output control: >40 dB ranges continuously adjustable.

Output balance: >40 dB below 20 kHz.

Distortion: <1% 5 Hz to 30 Hz and 100 kHz to 1.2 MHz; <0.1% 30 Hz to 100 kHz (Low Dist. Mode).

Hum and noise: <0.01% of output.

Operating temperature: (for specifications): 0°C to 55°C.

Voltmeter 403B Opt. 001

Range: 0.001 to 300 V rms full scale (12 ranges) in 1, 3, 10 sequence.

Frequency range: 5 Hz to 2 MHz.

Accuracy: within ±0.2 dB of full scale from 10 Hz to 1 MHz; within ±0.4 dB of full scale from 5 Hz to 10 Hz and 1 MHz to 2 MHz, except ±0.8 dB 1 to 2 MHz on the 300 V range (0°C to +50°C).

Meter: individually calibrated, taut band. Responds to average value of input waveform and is calibrated in the rms value of a sine wave.

Nominal input impedance: 2 MΩ; shunted by <60 pF on 0.001 V to 0.03 V ranges, <30 pF on 0.1 V to 300 V ranges.

DC isolation: signal ground may be ±500 V dc from chassis ground.

Patch panel, 353A

(specifications with oscillator and voltmeter)

Input (receiver)

Frequency range: 50 Hz to 560 kHz.

Frequency response: ±0.5 dB, 50 Hz to 560 kHz.

Balance: better than 70 dB at 60 Hz for 600Ω and 900Ω; better than 60 dB at 1 kHz for 600 and 900Ω; better than 40 dB over entire frequency range for 135, 600 and 900Ω.

Impedance: 135, 600, 900Ω and bridging (10 kΩ); center-tapped.

Insertion loss: <0.75 dB at 1 kHz.

Maximum level: +22 dBm (10 V rms at 600Ω).

Output (source) includes all receiver specifications and attenuation: 110 dB in 1 dB steps.

Accuracy: 10 dB section <±0.25 dB per step. 100 dB section, <±0.5 dB per step.

Available telephone patch panels

Patch panel 353A opt. H02 (same as Model 353A except as indicated).

Attenuator: 23 dB ±0.5 dB (1-step slide switch).

Hold circuit (send terminals)

Frequency response: 300 Hz to 3 kHz, ±0.5 dB, 1 kHz reference.

DC resistance: 240Ω NOMINAL.

Maximum dc current: 100 mA.

Maximum dc voltage: 150 V.

Connectors: special telephone jacks to accept Western Electric No. 309 and 310 plugs. Sleeve jack is connected to sleeve of jacks 309 and 310.

Patch panel 353A opt. H03 (same as Model 353A except as indicated).

Hold circuit (receive terminals)

Frequency response: 300 Hz to 3 kHz, ±0.5 dB, 1 kHz reference.

DC resistance: 240Ω NOMINAL.

Maximum dc current: 100 mA.

Maximum dc voltage: 150 V.

Attenuation: 23 dB ±0.5 dB (1-step slide switch).

Hold circuit (send terminals)

Frequency response: 300 Hz to 3 kHz ±0.5 dB, 1 kHz reference.

DC resistance: 240Ω NOMINAL.

Maximum dc current: 100 mA.

Maximum dc voltage: 150 V.

Connectors: special telephone jacks to accept Western Electric No. 309, 310 and 241 at send and rec terminals. Sleeve jack is connected to sleeve of jacks 309 and 310.

General

Power: specifications for both voltmeter and oscillator (patch panel has no power connector). 4 rechargeable batteries (furnished); 40 hr operation per recharge, up to 500 recharging cycles; recharging circuit is self-contained and functions automatically when instrument is operated from ac line (115 or 230 V ±10%, 48 to 448 Hz, total of 7 VA max).

Dimensions: 8⅜" high, 19¼" wide, 13¼" deep (with cover installed) (213 x 489 x 336 mm).

Weight: net, 30 lbs (13,5 kg); shipping, 41 lbs (18,5 kg).

Accessories furnished: detachable power cord; two 11035A Cables (1 foot long, dual banana-plug to BNC); the three instruments are enclosed in a 11046A Combining Case with a splash-proof cover.

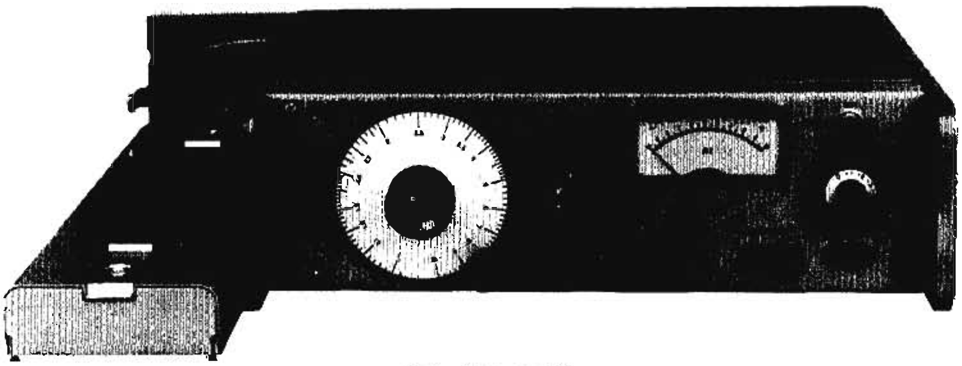
Price: HP 3550B (204C opt. H20, 353A and 403B opt. 001), $1255. HP 3550B opt. H02 (204C opt. H20, 353A opt. H02 and 403 opt. 001), $1375. HP 3550B opt. H03 (204C opt. H20, 353A opt. H03 and 403B opt. 001), $1375.

* For complete specifications refer to data sheet.

VIDEO TEST OSCILLATOR

Balanced, unbalanced, auto leveled outputs

Model 653A Option H01



653A Option H01

Description

The 653A Option H01 Test Oscillator is a lightweight, solid-state signal source primarily used in the adjustment of transmission characteristics of video loops. The output signal is automatically leveled to 0.05 dB for the sine wave output while monitoring 0.2 dB for all other functions. Use of the 653A Option H01 can reduce the number of individual pieces of test equipment on the sending end.

The 653A Option H01 includes a 60 Hz square wave, a simulated video signal, a modulated video signal, and a separate sync-only pulse. The simulated video signal, useful for qualitative monitoring, contains a blanking pulse, sync pulse, and white window. For video measurements and adjustments, the 653A Option H01 can replace the Western Electric 61C Signal Generator, 70B Power Meter, and HP 200CD Reference oscillator at the sending end. It can be used with the Western Electric 1 AP or 38 transmission comparing sets and associated cabling.

Adjustable test frequencies from 10 Hz to 10 MHz cover the complete video frequency range. The internal 300 kHz reference oscillator, conveniently selected by a front-panel switch for comparison measurements, eliminates the need for a separate reference oscillator. Amplitude stability, accuracy, and frequency response, good for 90 days from calibration, eliminate the need for the power meter at the sending end.

Front and rear covers provide protection and convenient cable storage space during transportation and periods when the instrument is not in use. The test set can be operated vertically on the floor or ground.

The 654A Test Oscillator is similar to the 653A except it is general purpose test oscillator. The internal 300 kHz reference oscillator is deleted. It has BNC output connectors, and the meter is calibrated in dBm. Output impedance of 50 and 75 ohms unbalanced and 135, 150, and 600 ohms balanced are selected by a pushbutton switch.

Specifications, 653A Opt H01

Frequency range: 10 Hz to 10 MHz in 6 bands.

Test frequency accuracy: ±1% at 4.5 MHz*; ±2%, 100 Hz to 5 MHz (on X100 range); ±3%, 10 Hz to 5 MHz; ±4%, 10 Hz to 10 MHz.

Reference accuracy (0 dB V): frequency, 300 kHz ±2%; level, ±0.1 dB for 90 days.

Output impedance: 75Ω unbalanced, 124Ω balanced.

Return loss (on 0 dB range and below): >40 dB to 5 MHz; >30 dB, 5 MHz to 10 MHz.

Output level: +11 dB V max to −90 dB V, 10 dB and 1 dB steps with adjustable ±1 dB vernier into 75Ω unbalanced or 124Ω balanced.

Overall attenuator accuracy sine wave: ±0.15 dB (±1 dB at output levels below −60 dB at frequencies >300 kHz). All other functions ±5%.

Meter range: ±1 dB V full scale.

Meter resolution: 0.02 dB.

Meter tracking accuracy: ±0.05 dB sine wave; ±0.2 dB all other functions.

Frequency response: (0 dB V, with meter centered, at end of recommended 6-ft cables); ±0.05 dB, 10 Hz to 10 MHz.

Balance: >50 dB, 10 Hz to 1 MHz; >40 dB, 1 MHz to 10 MHz.

Distortion (THD): >40 dB below fundamental, 10 Hz to 5 MHz; >34 dB, 5 MHz to 10 MHz.

Hum and noise: >70 dB below full output.

Output jacks: accepts WE 358A and 408A plugs; max dc voltage which can be applied to the output jacks, <±3 V p.

Counter output: >0.1 V rms into 50Ω, BNC connector.

Functions**

- Sine wave (standard operation).
- 60 Hz square wave, 0 dB V = 1 V p-p, risetime 2 T (T = 125 ns).
- Simulated video signal with sync pulse, blanking pulse and white window, 0 dB V = 1 V p-p, risetime 150 ns.
- Video signal modulated by 60 Hz square wave, 0 dB V = 1 V p-p, risetime 150 ns.
- Sync pulse only, 0 dB V = 0.25 V p-p, width 12.7 μs, risetime 150 ns.

General

Operating temperature: 32°F to 130°F.

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 35 VA max.

Dimensions (covers installed): 16¾" wide, 5" high, 16" deep (425 x 127 x 406 mm).

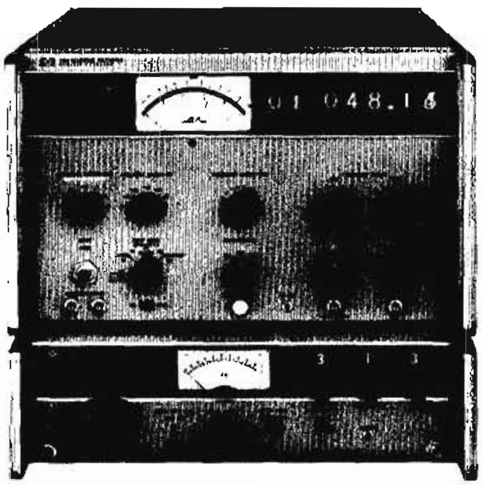
Weight: net, 21 lbs (9.5 kg); shipping, 31 lbs (14 kg).

Accessories furnished: rack mount kit, front cover, rear cover, 7.5-ft yellow power cord.

Price: HP 653 Opt H01, $1435.

*Accuracy for temperatures from 20°C to 30°C.
**Waveforms conform to EIA Spec. RS170.

SELECTIVE VM; OSCILLATOR
Signal analysis to 22 MHz; tracking oscillator
Models 312A; 313A



312A; 313A

Description

The Hewlett-Packard Model 312A/313A is a frequency selective voltmeter/tracking oscillator set operating in the frequency range of all commercially available carrier and radio systems including the Western Electric L4 system. The set is capable of making transmission and noise measurements with an unparalleled speed and accuracy resulting in a substantial time saving even when operated by inexperienced craftsmen.

The 312A uses a frequency synthesizer for tuning that is automatically phase locked in 1 MHz steps with no tuning clicking relays or flashing lights necessary to achieve lock. Tuning between lock points is indicated on a 7-place indicator tube readout with 10 Hz plus time-base accuracy. The frequency is unambiguous and can be set up easily by inexperienced craftsmen. Coupled with this digital indication of frequency is an automatic tuning aid known as automatic frequency control (AFC). The AFC will automatically fine tune the frequency to the center of the set's passband, eliminating the need for time consuming peaking of the meter indication. It will automatically correct for any relative frequency drift between the set and the signal being measured. Long term monitoring of pilots is possible without periodic readjustment. The high frequency accuracy coupled with AFC gives clear, instantaneous tuning with complete operator confidence and eliminates the need to search for signals or bump tones for identification.

Input and IF attenuators allow a maximum of dynamic range without concern for overloading the set. The attenuators can be easily set for maximum distortion or noise performance. Attenuator settings are indicated clearly on a lighted annunciator which, when added to the meter indication, gives a fast, error-free indication of input level. An accessory expanded scale meter allows 0.02 dB resolution of input level for accurate measurements.

The set is equipped with both balanced and unbalanced inputs to fit any measuring situation without the need for external accessory transformers. A wide selection of input impedances, either bridging or terminated, is provided along with provisions for an accessory high impedance, balanced bridging probe to eliminate measurement errors. The set always indicates directly in dBm or volts for any impedance without the need for time consuming calculations or conversion charts.

Three selectable bandwidths are provided for all measurement situations. A narrow 200 Hz bandwidth is used for highly selective measurements, a 1000 Hz bandwidth for general measurements, and a 3100 Hz bandwidth for noise measurements. The Model 312A Option 001 provides for channel noise measurements in dBrnc at carrier frequencies on operating systems similar to the Western Electric 7A. This allows easy troubleshooting of tough noise problems by making possible noise measurements of a noisy channel anywhere in the baseband spectrum.

Demodulation of upper or lower sideband channels with an audio output is provided for monitoring of noise, traffic, or tones in any channel. The inherent accuracy of the digital frequency readout requires only a quick reference to the system frequency charts to determine frequency for perfect demodulation—no tuning around for natural sounding demodulation is required. In this respect the Model 312A can be thought of as a single-channel, tuneable, multiplex, receive terminal.

The Model 313A Tracking Oscillator provides an accurate, flat output at the frequency to which the 312A is tuned for frequency response measurements. The output frequency is quickly and easily set by the digital tuning indicator on the selective voltmeter.

Output level is easily set by a 3-digit presentation with 0.1 dB resolution. Output level is also easily read and remains constant with changes in frequency requiring no time consuming resetting of level at each new frequency.

A built-in meter provides an expanded scale display of the 312A's meter indication with 0.02 dB resolution of input level.

Specifications, 312A

Tuning characteristics

Frequency range: 1 kHz to 18 MHz in 18 overlapping bands, 200 kHz overlap between bands.

Frequency accuracy: ±(10 Hz + time-base accuracy). Frequency indicated on in-line digital readout with ±10 Hz resolution.

Time-base stability

Aging rate: ±2 ppm per week.

As a function of ambient temperature: ±15° to +35°C, ±20 ppm; 0° to +55°C, ±100 ppm.

As a function of line voltage: ±0.1 ppm for changes of ±10%.

Selectivity

Rejection	200 Hz bandwidth	1000 Hz bandwidth	3100 Hz bandwidth
3 dB	200 Hz ±10%	1 kHz ±10%	3 kHz ±10%
60 dB	<470 Hz	<2350 Hz	<6680 Hz

(Midpoint of the band is marked by rejection notch 3Hz wide.)

Automatic frequency control

Dynamic hold-in range: ±3 kHz at 3.1 kHz bandwidth (0 dB ref.)

Tracking speed: 100 Hz/s; locks on to signals as low as 60 dB below zero reference. Zero reference level set with Amplitude Range switch set to 0 dB.

Amplitude characteristics

Amplitude range: 50 to 150Ω, −97 dBm to +23 dBm full scale: 600Ω, −107 to +13 dBm.

Voltage: 3 μV to 3 V full scale (50Ω reference).

Amplitude accuracy

Amplitude range: attenuator: ±0.1 dB (1% of reading).

Reference level attenuator: at 1 MHz, ±0.2 dB.

Frequency response (bridging input with external termination of 50Ω ±1%): 1 kHz to 10 kHz, ±0.5 dB (5% of reading; 10 kHz to 10 MHz, ±0.2 dB (2% of reading) 10 MHz to 18 MHz, ±0.5 dB (5% of reading).

Meter tracking: ±0.1 dB to −10 dB (1% of reading).

Internal calibrator output

Frequency: 1 MHz square wave (derived from time base).

Amplitude: −40 dBm into 75Ω termination.

Amplitude stability: ±0.1 dB.

Output connector: BNC female.

Matching impedance: 50, 60, 75, 124, 135, 150 or 600Ω, balanced or unbalanced.

Bridging impedance: 20 kΩ ±3% shunted by <30 pF (balanced): 10 kΩ ±3% shunted by <60 pF, reference level attenuator at −40 dB (unbalanced).

Common-mode rejection (balanced input): 10 kHz to 5 MHz, >40 dB: 5 MHz to 18 MHz, >30 dB.

Harmonic distortion: 1 kHz to 1 MHz, >55 dB below zero reference with Amplitude Range switch set at 0 dB; 1 MHz to 18 MHz, >65 dB below zero reference with Amplitude Range switch set at 0 dB.

Residual responses: 72 dB below zero reference with no input and reference level in any position.

Noise level, referred to input: 50 to 150Ω, −120 dBm (200 Hz bandwidth): 600Ω, −130 dBm (200 Hz bandwidth). Ref. level at 0.

Receiver characteristics

Receiver mode outputs:

AM and AM/AFC: diode-demodulated audio.

Beat: beat frequency audio center at f_o.

LSB: product-demodulated audio, carrier reinserted at f_o + 1.8 kHz.

USB: product-demodulated audio, carrier reinserted at f_o −1.8 kHz.

Audio output level: >0.5 V rms into 10 kΩ with full scale meter deflection.

Recorder output level: 1 V ±0.1 V with full-scale meter deflection across open circuit. Output connector, BNC female. Tracking accuracy, better than ±0.1 dB to 20 dB below full-scale reference on 0 dB position of Amplitude Range switch; better than ±0.2 dB to 30 dB below full-scale reference. Output resistance, 1 kΩ.

Auxiliary outputs

1 MHz: 1 V p-p sine wave into 1 kΩ; output connector, BNC female.

30 MHz: 40 mV to 70 mV rms into 50Ω; output connector, BNC female.

Local oscillator (30 to 48 MHz): 60 mV to 90 mV rms into 50Ω; output connector, BNC female.

Accessories available: 11530A Probe provides amplitude accuracy (probe and divider only) of ±0.5 dB; $225.

11143A Balanced Cable, 44" overall length (BNC to clip lead), $25.

5060-0216 Joining Bracket Kit for joining two-full-module instruments, $25.

Probe input impedance (at 1 MHz)

Probe divider	Input Impedance Unbalanced	Balanced
1:1 (0 dB)	20 kΩ shunted by <40 pF	40 kΩ shunted by <10 pF
10:1 (20 dB)	20 kΩ shunted by <12 pF	40 kΩ shunted by < 6 pF
100:1 (40 dB)	20 kΩ shunted by < 7 pF	40 kΩ shunted by < 4 pF

Power: 115 or 230 V ±10%, 50 to 400 Hz, 100 VA.

Weight: net, 46 lbs (20,8 kg): shipping, 62 lbs (28,1 kg).

Dimensions: 16¾" wide, 10¾" high, 18⅜" deep (425 x 273 x 467 mm); hardware furnished for conversion to rack mount 19" wide, 10-15/32" high, 16⅜" deep behind panel (483 x 266 x 416 mm).

Price: HP 312A, $4275.

Specifications for 312A, Option 001*

(Same as Standard Model 312A with following exceptions)

Bandpass: 3100 Hz with carrier rejection notched at ±2 kHz from the center of passband.

Rejection notches: down >55 dB at 2 kHz above and below center of passband; down >45 dB at ±7.5 Hz from center of rejection notch.

Price: 312A Option 001, add $100.

Specifications, 313A

Frequency range

As tracking oscillator: same as 312A (18 MHz) or (22 MHz). Refer to data sheet.

As signal source: 1 kHz to 22 MHz in one band, continuous tuning.

Frequency accuracy

As tracking oscillator: 35 Hz ±4 Hz above 312A tuning.

As signal source: ±1% of maximum dial setting from 10 kHz to 2 MHz; ±3% of maximum dial setting from 2 to 8 MHz; ±5% of maximum dial setting from 8 to 22 MHz.

Frequency stability

As tracking oscillator: same as 312A time base ±100 Hz/°C.

As signal source: short term (5 min) drift <1 kHz in stable environment after warmup.

Frequency response: ±0.1 dB, 10 kHz to 22 MHz.

Amplitude stability: ±0.1 dB for 90 days (0 to +55°C).

Meter mode

312A Expand: meter expands any 2 dB range of 312A meter indication from −7 to +3 dB using 312A recorder output. Meter range, −1 to +1 dB; tracking error, ±0.05 dB over full 2 dB range (operates with any 1 V, 1 kΩ recorder output).

Output monitor: meter indicates voltage level at the input of the attenuator and can be calibrated from the front panel.

Maximum output: 0 or +10 dBm ±0.1 dB, selectable at front panel.

Output attenuator: 3-section attenuator provides 0 to 99.9 dB attenuation in 0.1 dB steps.

Attenuator accuracy: 0.9 dB section (0.1 dB steps), ±0.02 dB; 9 dB section (1 dB steps), ±0.1 dB; 90 dB section (10 dB steps), ±0.1 dB to 50 dB, ±0.2 dB to 90 dB.

Output impedance: 75Ω unbalanced (50Ω optional, see Option 001 below).

Output connector: BNC female.

Harmonic distortion: >34 dB below fundamental.

Non-harmonic distortion

As tracking oscillator: >40 dB below fundamental.

As signal source: >50 dB below fundamental.

Recorder output: +0.3 V for full-scale deflection. Output impedance 1 kΩ, BNC female connector.

Power: 115 or 230 V ±10%, 50 to 400 Hz, 35 VA maximum.

Dimensions: 16¾" wide, 5½" high, 18⅜" deep (425 x 140 x 467 mm).

Weight: net, 25 lbs (11,3 kg); shipping, 30 lbs (13,6 kg).

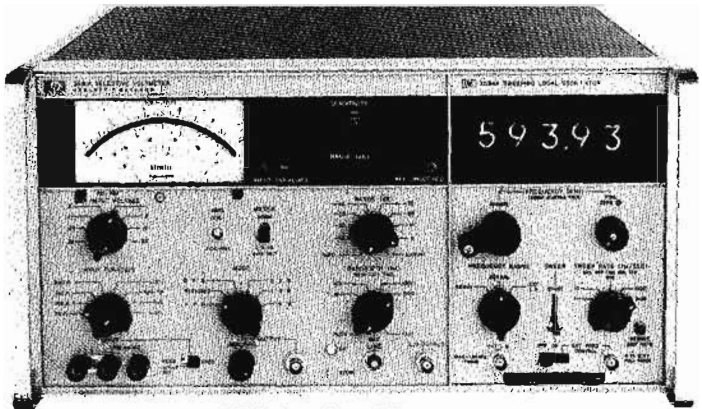
Accessories furnished: 11086A interconnecting cables for use with HP 312A, each cable 2 ft (610 mm) long with BNC male connectors (3).

Price: HP 313A, $1400.

Option 001: output impedance 50Ω unbalanced; no additional charge.

*For other special 312A's, refer to your nearest Hewlett-Packard Sales Office.

PLUG-IN SELECTIVE VOLTMETER
Balanced inputs of 75Ω to 600Ω and bridging
HP 3591A, 3594A



3591A with 3594A Plug-in

The HP Model 3591A Plug-in Selective Voltmeter is designed specifically for communications systems. The input balanced impedances and the input functions, in addition to all of the features of the 3590A, make it outstanding as a communications test instrument.

Specifications‡

Frequency range: 20 Hz to 620 kHz.

Amplitude ranges: 3 μV to 30 V full scale in 15 ranges.

Amplitude accuracy with input terminated

Meter switch in normal position: overall accuracy: ±0.43 dB to ±0.67 dB of reading depending on frequency, including:

Frequency response flatness, total deviation: 600 ohm: 20 Hz to 100 Hz ±0.53 dB (±5%): 100 Hz to 620 kHz ±0.26 dB (±3%).

All other terminations: 5 kHz to 620 kHz ±0.26 dB (±3%).

Meter tracking: ±0.1 dB or ±1% of reading, 0 dB to −10 dB.

Meter switch in linear dB position: overall accuracy: ±1 dB.

Internal calibrator: frequency, 100 kHz ±10 Hz; Amplitude, full scale on 0 dB range in CAL mode: accuracy, ±0.1 dB.

Dynamic range: (IM and harmonic distortion products).

>85 dB below zero dB reference level when ABSOLUTE measurements are being made (>70 dB 20 Hz to 50 Hz).

>80 dB below zero dB reference level when RELATIVE adjustment is used (>70 dB for 20 Hz to 50 Hz).

Residual responses

>80 dB below zero reference (>70 dB for 20 Hz to 50 Hz).

Return loss: 100 Hz to 620 kHz, 600Ω >30 dB; 5 kHz to 620 kHz, 150Ω, 135Ω, 75Ω, >35 dB.

Noise level:

Bandwidths	Input noise level (600Ω input impedance)
10 Hz and 100 Hz	< −125 dBm or 0.44 μV
1 kHz and 3.1 kHz	< −115 dBm or 1.38 μV

Selectivity:

Rejection	10 Hz	Bandwidths 100 Hz	1 kHz	3.1 kHz
3 dB	10 Hz	100 Hz	1 kHz	3.1 kHz
60 dB	35 Hz	320 Hz	3.1 kHz	9.6 kHz

(Frequency accuracy ±10%)

Automatic frequency control

Capture threshold: 75 dB below 0 dB reference.

Dynamic hold-in range: >3 bandwidths.

Tracking rate proportional to bandwidth.

Inputs: balanced or single-ended, not floating; term. or brdg.

Input functions

dBm: levels calibrated in dBm for impedances selected.

Abs Vm: level calibrated in volts.

Rel: input level can be set arbitrarily to 0 dB Ref. (10 dB set level range).

Cal: internal level calibrator.

Input impedances*

Resistances: 75Ω, 135Ω, 150Ω, 600Ω terminated: 50 kΩ (single ended bridging) and 100 kΩ (balanced bridging).

Capacitance (each terminal to ground): 10 mV, 30 mV ranges <55 pF; 100 mV to 30 V ranges <40 pF.

Common mode rejection: 20 Hz to 620 kHz, >40 dB.

Automatic ranging: 8 ranges, 0 dB to −70 dB. Ranging rate proportional to bandwidth.

Output: amplitude: adjustable 0 to 1 V rms open circuit.

BFO frequency response flatness: ±0.2 dB or ±2%.

Resistance: 600Ω.

L.O. output: frequency, 1.28 MHz to 1.90 MHz (1.28 MHz + tuned frequency); amplitude, 0.65 V rms ±20% open circuit; resistance, 250Ω.

Recorder outputs:

X-Axis (3593A/3594A only)	Plug-in Frequency Ranges 62 kHz	620 kHz
X-axis linear output: (1 kΩ source resistance)	0 to −12.4 V (200 mV/kHz ±5%)	0 to −12.4 V (20 mV/kHz ±5%)
X-axis log output: (1 kΩ source resistance)	5 V/decade ±5% (50 Hz - 62 kHz)	5 V/decade ±5% (500 Hz - 620 kHz)

Y-Axis:

Linear Y axis output: +10 V dc ±2% for full scale meter indication, 1 kΩ source resistance.

Log Y axis output: +1 V to +10 V dc, proportional to linear dB meter indication (−90 to 0 dB, 0.1 V/dB) 1 kΩ source resistance.

Power: 115 V or 230 V ±10%, 50 Hz to 400 Hz, <70 W.

Dimensions: 16¾″ wide, 8¼″ high (without removable feet), 16⅜″ deep (425 x 210 x 416 mm).

Weight: net, 37 lbs (16,8 kg); shipping, 47 lbs (21,3 kg).

Accessories furnished: rack mounting kit for 19″ rack. (Refer to page 447 for plug-in information. The 3591A must have a plug-in to operate.)

Price: HP 3591A, $3435.

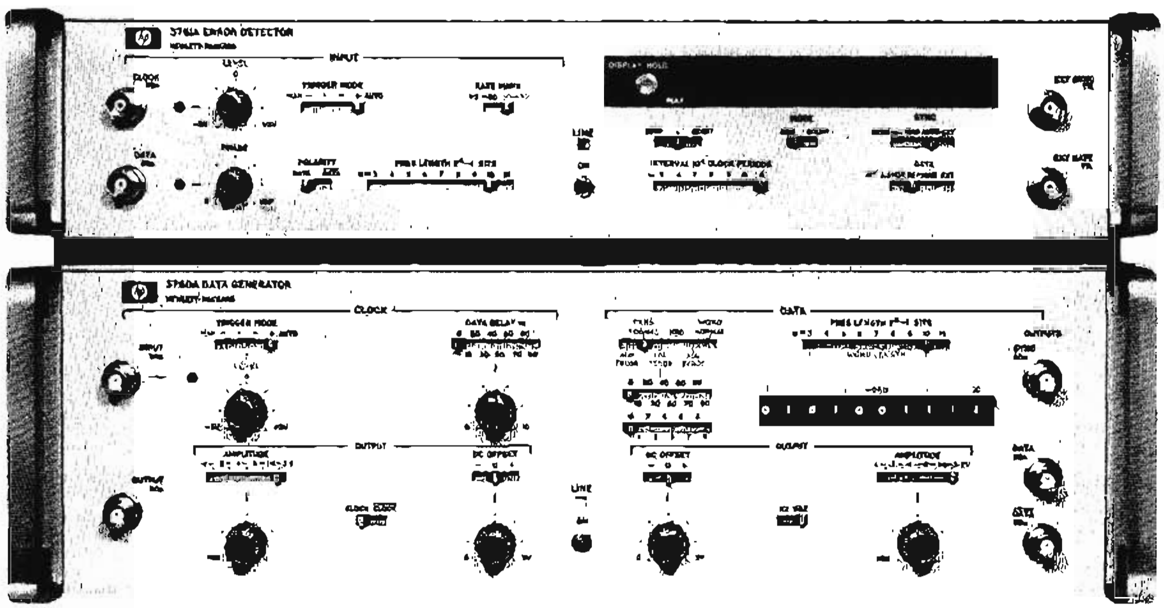
Plug-ins: HP 3592A, $80; HP 3593A, $1130; HP 3594A, $1640.

*Other terminations available on special order.
‡For complete specifications refer to data sheet.

ERROR RATE MEASUREMENT

Error detection up to 150Mb/s

Models 3760A, 3761A



NEW

3760A/3761A

The 3760A/61A Error Rate Measuring system is a generator and a receiver operating at rates up to 150 Mb/s. The 3760A Data Generator provides a variable length PRBS to the item under test, the output of which is analyzed by the 3761A Error Detector.

The Error Detector has a built-in counter with two modes of operation: Bit Error Rate (BER) and Total Error Count (COUNT). In BER mode, the measurement is displayed in the form a·b x 10^{-x}. In COUNT mode, the errors accumulated in a chosen interval are displayed as a four digit number with leading zeros blanked.

The 3760A Data Generator is a 150 Mb/s versatile PRBS and WORD generator having many features which make it especially attractive for high frequency digital communications. Its features are described fully in the Data Generator Model 3760A Data Sheet, and only those which apply to Bit Error Rate Measurement are described here.

The Data Generator has a versatile clock input which will accept regular waveshapes in the frequency range 1.5 to 150 MHz, and an output is available of the clock or its complement, $\overline{\text{clock}}$. It produces pseudo random binary sequences, variable in length from $2^3 - 1$ to $2^{10} - 1$ bits, with an additional long sequence of $2^{15} - 1$ bits. This data and its complement, $\overline{\text{data}}$, are provided as separate outputs, and can be delayed with respect to the clock by up to 100 ns.

Both the clock and data outputs are continuously variable in amplitude and offset to provide the capability of directly interfacing with a wide range of systems. For back-to-back testing of the Data Generator and Error Detector, one error can be introduced every 2000 sequences.

The 3761A Error Detector has been specifically designed for operation with the pseudo random sequences produced by the Data Generator. It requires both clock and data inputs, and performs error detection using bit-by-bit comparison with an internally generated, closed loop, reference sequence. This technique ensures detection of every error, random or systematic, and avoids the problems associated with open loop reference sequence generation.

The BER measurement is computed from more than 100 errors, and has a range of 9.9 x 10^{-1} to 0.1 x 10^{-9}. The total error count, COUNT, which has a range of 0 to 9999, is provided with both internal and external gating. The internal gating period can be selected within the range 10^5 to 10^{11} clock decades and can be single shot or repetitive in operation. A TTL compatible external gate input is provided, and manual gating is controlled with a front panel stop/start switch. In both BER and COUNT modes, the display is continually updated at a rate which may be set by the operator.

The 3761A Error Detector clock input (impedance 50Ω, optionally 75Ω) accepts regular waveshapes in the frequency range 1.5 to 150 MHz. It has a sensitivity of better than 500 mV pk-pk and can be triggered manually or automatically on the +ve or −ve slope of the input waveform. The range of the manual trigger control is +3 to −3 V, and indication of correct trigger is given by a front panel lamp. The auto trigger will accept mark: space ratios in the range 10:1 to 1:10 subject to a 3 ns minimum pulse width.

The data input conditions for frequency range, waveshape, impedance and sensitivity are identical to those for the clock. The data input triggering is automatic with compensation for dc offsets in the range +3 to −3 V. The input can be inverted with a data/$\overline{\text{data}}$ switch to allow for an inversion in the item or system under test.

A front panel variable phase control is used to ensure that coincidence between clock and data edges is avoided. At frequencies up to 50 MHz the control range is 0 to 180° and from 50 to 150 MHz it is 0 to 12 ns. A lamp indicates when a correct phase relationship between the clock and data has been attained.

Synchronization of the 3761A Error Detector to the incoming data can be accomplished automatically, manually, or externally. In the automatic mode, correct synchronism is ensured by continually monitoring the average error rate over a period long enough to remove the effect of error bursts. In the manual synchronization mode the Error Detector searches for synchronism on command from a front panel switch, and in the external mode by command from an external TTL signal.

A BCD output of the current display is available from a rear panel socket. This output is in 8421 format and includes the sync loss and overflow flag indications. An output of one pulse per error is also available at the rear panel for further analysis.

Specifications

Measurements

Bit Error Rate, BER
- **Range:** 9.9×10^{-1} to 0.1×10^{-9}, automatically scaled.
- **Gating:** Automatic, at least 100 errors before computation.

Total Error Count, COUNT
- **Range:** 0 to 9999.
- **Gating:**
  - **Internal:** Repetitive or single shot.
    - **Interval:** 10^n clock periods where integer $n = 5$ to 11.
  - **External:** Logic level TTL.
  - **Manual:** Front panel switch.

Sequences: Maximal length PRBS.
- **Lengths:** $2^N - 1$ where $N = 3$ to 10 and 15.

Data generator

Clock Input
- **Rate:** 1.5 to 150 MHz.
- **Impedance:** 50Ω ±5% dc coupled (75Ω optional).

Trigger
- **Slope:** +ve or −ve.
- **Manual:** Level range: −3 to +3 V.
- **Auto:** Input mark: space ratio range 10:1 to 1:10.

Sensitivity: Better than 500 mV pk-pk.

Amplitude: ±5 V maximum.
- **Pulse Width:** 3 ns minimum at 50% pulse amplitude.

Clock Output
- **Outputs:** CLOCK or $\overline{\text{CLOCK}}$.
- **Impedance:** Source impedance 50Ω ±5% (75Ω optional).
- **Amplitude:** Continuously variable in 5 ranges from 0.1 to 3.2 V into 50Ω symmetrical about offset level.
- **Rise/fall time:** <1 ns (10% to 90% level).
- **DC Offset:** Variable, 0 to ±3 V.

Data Output
- **Outputs:** DATA and $\overline{\text{DATA}}$.
- **Impedance:** 50Ω ±5% (75Ω optional).
- **Amplitude:** Continuously variable in 5 ranges from 0.1 to 3.2 V into 50Ω symmetrical about offset level.
- **Rise/fall time:** <1 ns (10% to 90% level).
- **DC offset:** Variable, 0 to ±3 V.
- **Delay:** Data (and sync) delayed with respect to clock continuously in 10 ranges from 0 to 100 ns.

Sync Output
- **Rate:** Once per PRBS.
- **Position:** Front Panel selectable.
- **Amplitude:** +1 V into 50Ω.

Error detector

Clock Input
- Specifications as for Data Generator Clock Input.

Data Input
- **Input:** DATA or $\overline{\text{DATA}}$, selectable.
- **Rate:** 1.5 to 150 Mb/s.
- **Impedance:** 50Ω ±5% dc coupled (75Ω optional).
- **Trigger Level:** Automatic. Input mark: space ratio range 10:1 to 1:10.
- **Sensitivity:** Better than 500 mV pk-pk.
- **DC Offset:** ±3 V maximum.
- **Amplitude:** ±5 V maximum.
- **Pulse Width:** 5 ns minimum at 50% pulse amplitude.

Phasing
- **Control:** Clock phase variable relative to data.
- **Indication:** Lamp off when clock and data edges coincide.

Range: 1.5 to 50 Mb/s: 0 to 180°.
50 to 150 Mb/s: 0 to 12 ns.

Synchronization
- **Modes:** Auto, Manual, External. External and Manual initiate single shot Auto sync.
- **Auto:** Automatically searches for synchronism if more than 20,000 errors in 100,000 bits.
- **External:** Resynchronization commanded by TTL input.
- **Manual:** Resynchronization commanded from front panel.

Display
- **BER:** Two digits plus exponent $a.b \times 10^{-x}$.
- **COUNT:** Four digits.
- **Flags:** Sync loss, overflow and gating.

Outputs
- **Printer:** 8421 BCD.
- **BER and COUNT:** Current display on command.

Flags:
- **Sync loss:** 0 printed in column 1.
- **Overflow:** Output inhibited.
- **Print command:** pulse at display change.

Error Output
- **Rate:** One pulse per error.
- **Amplitude:** +1 V into 50Ω.

Accuracy
- **BER:** Computation based on at least 100 errors.
- **COUNT:** Internal gating, ±1 error.

Options

3760A Data Generator
- **Option 001:** 75Ω CLOCK and DATA input/output impedances.
- **Option 002:** Internal variable frequency clock.
- **Option 003:** Options 001 and 002 combined.

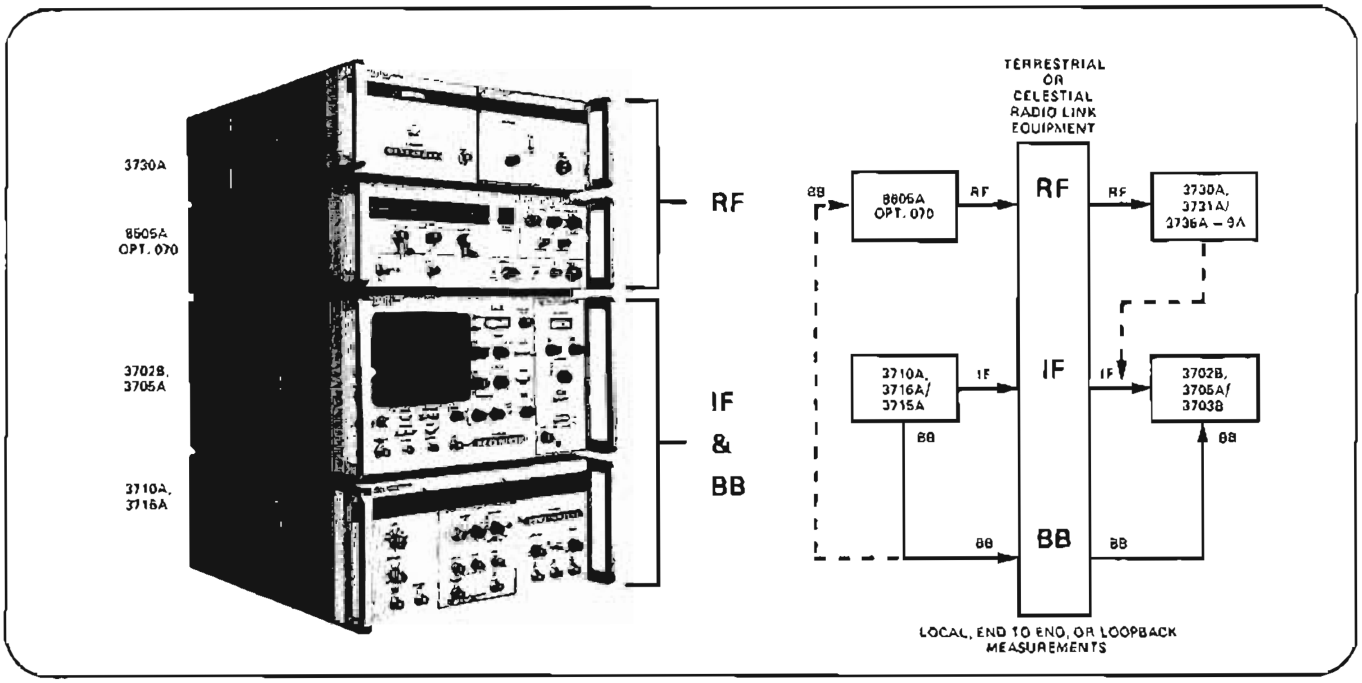
3761A Error Detector
- **Option 001:** 75Ω CLOCK and DATA input impedances.
- **Option 002:** Printer interface cable.

General

Data Generator
- **Power:** 90 to 125 V or 200 to 250 V, 40 to 400 Hz, 90 W.
- **Dimensions:** 16¾ in wide, 5½ in high, 18¾ in deep. (425 mm x 140 mm x 467 mm).
- **Weight:** 30 lbs (13,6 kg).

Error Detector
- **Power:** 90 to 125 V or 200 to 250 V, 40 to 400 Hz, 70 W.
- **Dimensions:** 16¾ in wide, 3¾ in high, 18¾ in deep. (425 mm x 95 mm x 467 mm).
- **Weight:** 23 lbs (10,4 kg).

MICROWAVE LINK ANALYSIS
At BB, IF & RF
Models 3710A/3702B, 3730A



Description

The Microwave Link Analyzer, Down Converter and Communications Sweep Oscillator, as a package, enables the full BB, IF & RF capability of terrestrial and celestial radio links to be realized. The Microwave Link Analyzer (3710A, 3716A/3715A, 3702B, 3705A/3703B) is a combined Baseband (BB) and Intermediate Frequency (IF) analyzer, allowing the various forms of distortion occurring in a link to be identified, measured and localized to BB and IF devices. The Down Converter (3730A) and Communications Sweep Oscillator (8605A Opt. 070, see page 440), which is used as an Up Converter, ensure that this capability is extended into the RF range. The Down Converter may be used independently of the Hewlett-Packard Microwave Link Analyzer.

Benefits

- An easy to operate, four instrument package.
- Comprehensive BB frequency coverage, 83.3 kHz to 8.2 MHz.
- Comprehensive IF coverage, 45 to 95 MHz.
- Comprehensive RF coverage, 1.7 to 11.7 GHz.
- Minimum cabling interconnections and alterations for changes in measurement.

MLA: seven selected baseband test tones up to 8.2 MHz.

- Internal demodulation up to 5 6 MHz.
- Inbuilt CRT with dual trace display.
- Receiver can be remote from transmitter for between station measurements. Slave facility for local display of remote measurements.
- IF frequency stability of ±100 kHz.
- IF frequency markers of 70 MHz, 2 MHz "comb" and sliding symmetrical pair.

RF capability: permits separate characterization of transmitter and receiver by BB, IF, or RF to RF tests. No plotting and differentiating—easy equalization. Permits active and passive component tests—avoids the problems of other systems.

Specifications
MLA

IF frequency range: 45 to 95 MHz centered on 70 MHz.
IF flatness (residual): ±0.05 dB from 45 to 95 MHz.
BB linearity and differential gain (residual): 0.1% (BB-BB), 0.4% (IF-IF) from 45 to 95 MHz.
Group delay (residual): 0.1 ns (BB-BB), 1 ns (IF-IF) from 45 to 95 MHz.
Differential phase (residual): 0.1° (BB-BB), 0.6° (IF-IF) from 45 to 95 MHz.
IF power range: +12 dBm to −10 dBm.
BB power range: −10 dBm to −49 dBm.
Modulator sensitivity: −49 dBm to 0 dBm.
Demodulator sensitivity: −10 dBm to −49 dBm.
Impedances: 75Ω.
Power: 115 or 230 V (±10%), 48 to 66 Hz, approx 190 VA.
Dimensions:
3710A: 16¾" wide, 6¾" high, 18" deep (425 x 172 x 457 mm).
3702B: 16¾" wide, 8½" high, 18" deep (425 x 216 x 457 mm).
Price: complete MLA systems, approx $10,500 to $12,000.

Down converter

RF input
RF frequency range: 1.7 to 12 GHz.
Minimum input level: −20 dBm (−44 dBm with Opt 010).
Impedance: 50Ω.
Minimum operating range (with MLA): +2 dBm to −16 dBm; with Opt. 010: +2 dBm to −41 dBm.
IF output
Meter accuracy: ±0.5 MHz at 70 MHz, (±2 MHz f.s.).
Return loss: 28 dB min.
Impedance: 75Ω.
Power: 115 or 230 V (±10%), 48 to 66 Hz.
Dimensions: 16¾" wide, 5½" high, 18⅜" deep (425 x 141 x 467 mm).
Price: mainframe, $2855; osc plug-ins approx $1500 to $2000.

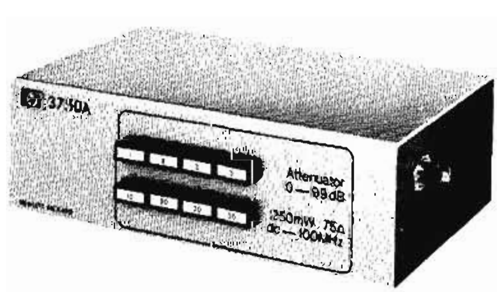
OPTION SELECTION CHART

Instruments to suit customer requirements may be compiled from the following groups. Specify only ONE option from each group	3710A	3716A	3715A	3702B	3705A	3703B	8605A	3730A
CONNECTORS								
	STD	STD	STD	STD	–	–	050/051	STD
Siemens large	002	002	002	002	–	–	•	002
Siemens small	003	003	003	003	–	–	•	003
Commercial equivalent of WECO 477B	004	004	004	004	–	–	•	004
with 75/124Ω bal	004	–	–	004	–	–	–	–
Type N (for RF)	–	–	–	–	–	–	STD	STD
BB FREQUENCIES								
83.3, 250, 500kHz	–	–	STD	–	–	STD	–	–
83.3, 250, 500kHz and 2.4, 4.43, 5.6, 8.2MHz	–	STD	–	–	STD	–	–	–
92.593, 277.778, 555.556kHz with phase lock control	–	–	009	–	–	009	–	–
92.593, 277.778, 555.556kHz, 2.4, 3.58, 5.6, 8.2MHz	–	010	–	–	010	–	–	–
92.593, 277.778, 555.556kHz, 2.4, 3.58, 4.43, 8.2MHz	–	011	–	–	011	–	–	–
SWEEP FREQUENCIES	OPTIONS							
70Hz internal	STD	–	–	STD	–	–	–	–
50Hz internal	006	–	–	STD	–	–	–	–
100Hz internal	007	–	–	STD	–	–	–	–
18Hz internal with bandwidths of 90 and 100Hz	STD	–	–	STD	015	015	–	–
VARIABLE PHASE SWEEP	OPTIONS							
0° ±100° and 180° ±100° from 45 to 100Hz	008	–	–	–	–	–	–	–

RF FREQUENCIES	DOWN CONVERTER PLUG-INS: 3731A	3736A	3737A	3738A	3739A
1.7 to 4.2GHz	–	STD	–	–	–
3.3 to 6.5GHz	–	–	STD	–	–
5.9 to 6.5GHz	STD	–	–	–	–
6.3 to 9.05GHz	–	–	–	STD	–
10.7 to 11.7GHz	–	–	–	–	STD

SYSTEM SELECTION CHART

Measurement	MLA				UP CONVERTER	DOWN CONVERTER	
	3710A	3716A/3715A	3702B	3705A/3703B	8605A, Opt. 070	3730A	3731, 6–9A
BB to BB							
BB to IF							
BB to RF							
IF to BB							
IF to IF							
IF to RF							
RF to BB							
RF to IF							
RF to RF							



3750A

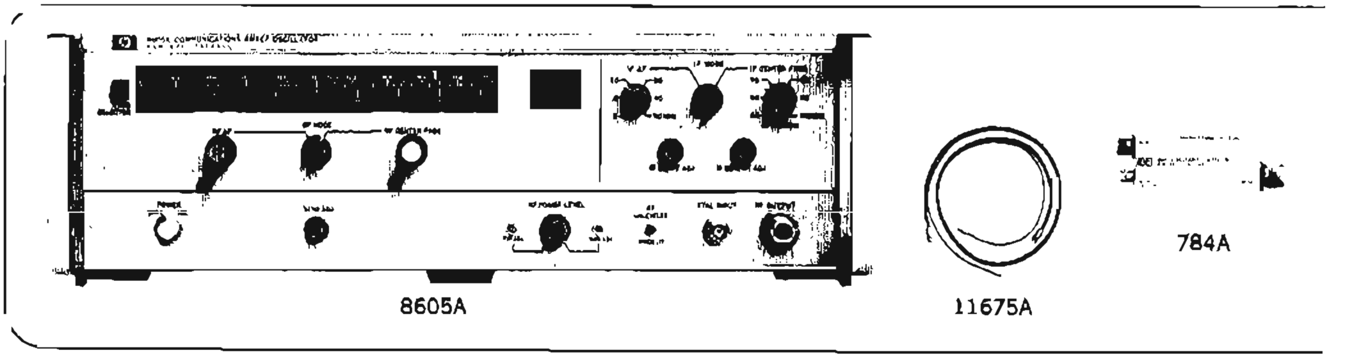
Description

The Model 3750A Attenuator is a general purpose 75Ω attenuator, being particularly suitable for the large value attenuation of radio frequency signals. The 3750A is symmetrical in design so that either port can be used as the input or output.

Specifications

Attenuation: 0 to 99 dB in 1 dB steps.
Frequency range: dc to 100 MHz.
Cumulative attenuation accuracy: ±2 dB for 99 dB.
Impedance: 75Ω.
Power dissipation: +24 dBm (250 mW).
Price: $180.

COMMUNICATIONS SWEEP OSCILLATOR AND ACCESSORIES
Model 8605A



Description

The Hewlett-Packard Model 8605A Communications Sweep Oscillator is an all solid state CW and swept source which offers 47 to 100 MHz IF coverage and multiband RF coverage. Multiband RF coverage is available anywhere in the microwave region, 1.7 to 13.25 GHz. While 4, 6 and 11 GHz bands are standard options almost any other band or bands are available upon request.

The instrument is easy to use and features excellent frequency accuracy and extremely flat power output characteristics (0.01 dB). The 70 MHz IF sweep generator controls are on the right of the mainframe, the multiband RF (microwave) controls are separate and on the left of the mainframe. The multiband RF section features a band switching lever for convenient control of RF frequency range and a highly adaptive multiband, modular design that enables Hewlett-Packard to offer self-contained multiband capacity anywhere in the 1.7 to 13.25 GHz region. The 8605A option 070 can also be used as a baseband to RF upconverter for the Hewlett-Packard Link Analyzer. For a description of this system see page 438.

General instrument specifications

Sweep frequency: adjustable from 20 to 40 sweeps per second.
Sweep output: direct-coupled sawtooth, zero to approx. +10 V.
Blanking output. 0 V during trace, +15 V during retrace.
Furnished: 7½' (2290 mm) power cable with NEMA plug, rack-mounting kit, and accessory kit.
Power: 115 or 230 V ±10%, 50 to 400 Hz; approx 150 watts.
Dimensions: 5¼" (133,4 mm) high, 16⅜" (416,0 mm) deep, 16¾" (425,5 mm) wide.
Weight: (including RF section) 33 lbs (15,0 kg); shipping, 48 lbs (21,8 kg).

70 MHz IF Section Specifications

Frequency range: 47 to 100 MHz.
ΔF sweep width range: 0 to 53 MHz.
Frequency accuracy (25°C): CW mode; ±2 MHz; Cardinal markings every 5 MHz; rear panel BNC counter monitor jack provided.
Residual FM-CW mode: <1 kHz peak.
Linearity: ΔF sweep mode, ±2.5%, as a % of sweep width.
Maximum leveled power output: >+10 dBm; internally leveled.
Power output variation (internally leveled): 55 to 85 MHz: <0.01 dB peak to peak; 47 to 100 MHz: <0.025 dB peak to peak.
Power output slope adjustment range: 0 to + 0.2 dB slope control.
Spurious signals: (down from fundamental output at +10 dBm); harmonics, more than 40 dB; non-harmonics, more than 50 dB.
IF output: 75 ohm WECO 567A jack; other connectors available.

Ordering information

Model 8605A Communications Sweep Oscillator: price includes 70 MHz IF section and RF bands specified optionally below.
Optional RF bands (order only one option)

4 GHz band,	Option 001;	Price: $4185
6 GHz band,	Option 002;	$4450
11 GHz band,	Option 003;	$4650
4 & 6 GHz bands,	Option 004;	$5075
4 & 11 GHz bands,	Option 005;	$6225
6 & 11 GHz bands,	Option 006;	$6425
4, 6 & 11 GHz bands,	Option 007;	$6775
Other bands,	Request Hewlett-Packard quotation	

Connector and modulation options
Option 050: 75-ohm BNC in place of WECO-567A for IF output; **Price:** no charge.
Option 070: external FM input for use as up-converter with Hewlett-Packard Microwave Link Analyzers; **Price:** add $250.
Model 11675A Leveling Cable Assembly; Price: $50.
Model 784A Directional Detector; Price: $625.

Band	Frequency Range	Frequency Accuracy CW-Mode	Linearity % of Sweep Width	Max. Leveled Power Incl. 784A	Power Variation: Over 30 MHz Channel	Power Variation: Over specified Band	Spurious Signals down from fundamental: Harmonic	Spurious Signals down from fundamental: Non-Harmonic	External FM-Option 070: Rate
4 GHz	3.65 to 4.25 GHz	±5 MHz	±1.0%	>+13 dBm (> 20 mw)	<±0.01 dB	<±0.15 dB	>−40 dB	>−60 dB	DC to 8 MHz
6 GHz	5.9 to 6.5 GHz	±8 MHz	±1.0%	>+13 dBm (> 20 mw)	<±0.01 dB	<±0.15 dB	>−40 dB	>−60 dB	DC to 8 MHz
11 GHz	10.7 to 11.7 GHz	±10 MHz	±2.0%	>+10 dBm (> 10 mw)	<±0.01 dB	<±0.2 dB	>−40 dB	>−60 dB	DC to 8 MHz
Other	Portion of 1.7–13.25 GHz	±0.5% of band width	±1.0% to ±2.0%	depends on band	<±0.01 dB	depends on band	depends on band	typically >−60 dB	DC to 8 MHz

Distortion analyzers

The goal of audio and communications equipment is to reproduce input signals faithfully at the output. System nonlinearity distorts the waveshape of the signals. Poor reproduction brought about by distortion will appear to the user of audio equipment as a change in the quality or as noise; to the user of communications gear, it appears as channel crosstalk.

Distortion in amplifiers, created by nonlinear circuits, consists of components present in the output that are not contained in the input signal. An ac signal that appears to be a pure sine wave as viewed on an oscilloscope (Figure 1) may have some *harmonic distortion*. The total of these frequency components present in the signal, in addition to the fundamental frequency, can be measured quickly and easily with Hewlett-Packard distortion analyzers.

One type of distortion analyzer contains a narrow band rejection filter which, when properly tuned, removes the fundamental frequency so that the amplitude of the remaining components can be measured simultaneously. Hewlett-Packard distortion analyzers are used for fast *quantitative* measurements of total harmonic distortion and noise.

Total harmonic distortion analysis

This measurement technique compares the amplitude of the harmonics to that of the original signal at the output where the original signal becomes the fundamental frequency of the harmonics. The defining equation is:

$$(1) \quad \text{total harmonic distortion} = \frac{\sqrt{\Sigma(\text{harmonics})^2}}{\text{fundamental}}$$

A frequency-selective voltmeter is needed to measure the fundamental, and either a selective voltmeter with a wide dynamic range or a frequency rejection circuit with a true rms detector is needed to measure the harmonics. The frequency rejection circuit nulls the fundamental and passes its harmonics to the detector with no attenuation so that the ratio between the fundamental and harmonics can be determined.

A less expensive way to measure the total harmonic distortion, however, is to use a rejection filter and a broadband detector. Since the fundamental is not directly measured, the equation becomes

$$(2) \quad \text{THD} = \frac{\sqrt{\Sigma(\text{harmonics})^2}}{\sqrt{(\text{fundamental})^2 + (\text{harmonics})^2}}$$

If the distortion is less than 10%, the denominator of equation 2 will be within ½% of the denominator in equation 1, which is as accurate as any frequency selective voltmeter.

There are two difficulties in making total harmonic distortion measurements. First, to get a measurement within the desired accuracy, the harmonic content of the test signal must not be more than a third of the distortion expected to be caused by the system. Second, the chore of nulling the fundamental can be time-consuming. Oscillators that meet the distortion requirements and nulling equipment, which has recently become available, can overcome the difficulties.

Automatic null

Since the nulling of the fundamental is normally the time-consuming portion of total harmonic distortion measurement, great savings can be realized, especially in production line testing with an analyzer which automatically rejects the fundamental. The time saved is as much as 25 seconds of a 30-second measurement. With automatic nulling, the accuracy of the null achieved is no longer a function of operator training, manual dexterity, or signal source frequency drift.

The analyzer will maintain a null even though there is a slow drift in the input frequency. This ability to "pull" the null has opened the door to a number of applications where the total harmonic distortion measurements were not readily applied in the past. Among them are:

1. Single-frequency production line testing of such components as integrated-circuit amplifiers or transformers. As long as the long term drift of the signal source is less than +1%, a good null will be achieved.
2. Optimizing the performance of an oscillator. Here, any variation in the parameters causes the frequency to shift slightly. The automatic nulling of the analyzer allows the oscillator performance to be improved on a continuous basis rather than by relying on a point-to-point check which may or may not find the optimum point.
3. Correcting distortion in signal generators which produce sine waves by mixing or by nonlinear shaping. The small frequency shifts would cause the loss of the null if it were not for the automatic null feature.

Selecting an analyzer

Distortion analyzers may be regarded as the inverse of wave analyzers. Distortion analyzers remove any signal component to which they are tuned, having the rest of the signal for measurement. In practice, distortion analyzers are tuned to the fundamental frequency and, by measuring the amplitude of the remaining harmonic components all at once, they provide an indication of percentage total harmonic distortion. Distortion analyzers do not provide information about individual distortion products—wave analyzers (see page 444) and spectrum analyzers (see page 450) do this job, but they do not provide fast readings of the signal's total departure from sine wave purity.

Table 1 describes the models and features of Hewlett-Packard distortion analyzers.

Option 001, for each model, features VU meter characteristics conforming to FCC requirements.

Table 1

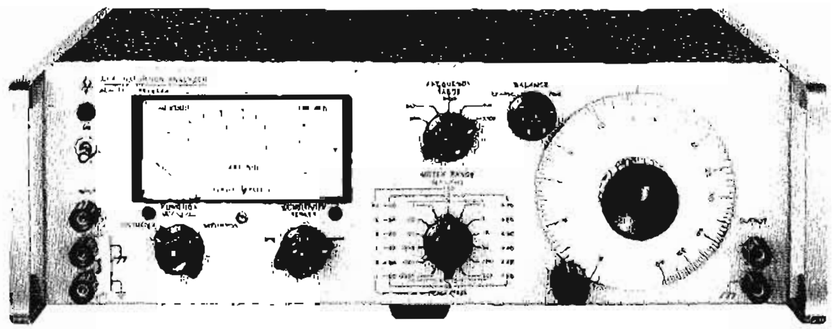
Model No.	Auto Nulling	Hi-Pass Filter	Lo-Pass Filter	AM Detector	Gear Reduction Tuning
331A					X
332A				X	X
332A Opt. H05			X	X	X
333A	X	X			
334A	X	X		X	
334A Opt. H05	X		X	X	

Optional, for each model, features VU meter characteristics conforming to FCC requirements.

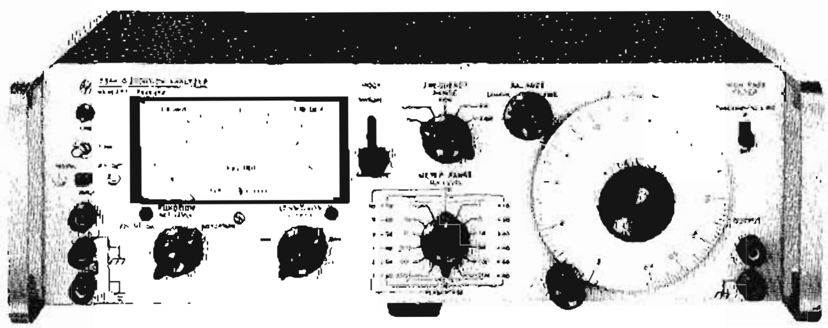
DISTORTION ANALYZERS

Manual or auto tuned; FCC approved

Models 331A, 332A, 333A, 334, Options



331A



334A

Description

Models 331A, 332A, 333A and 334A Distortion Analyzers measure total distortion down to 0.1% full scale at any frequency between 5 Hz to 600 kHz; harmonics are indicated up to 3 MHz. These instruments measure noise as low as 50 microvolts and measure voltages over a wide range of level and frequency. All four models may be used as sensitive wide range transistorized voltmeters for general purpose voltage and gain measurements. The transistorized ac voltmeter provides 13 ranges from 300 μV to 300 V rms full scale.

The HP Models 332A, 332A Option H05, 334A and 334A Option H05 Analyzers are provided with an amplitude modulation detector having a frequency range from 550 kHz to greater than 65 MHz.

The Model 334A is similar to Model 332A, but is provided with automatic fundamental nulling and a high pass filter. A switchable low-pass filter is available in the 332A Option H05 and 334A. Refer to Table 1 on Page 441 for available features.

Specifications, 331A

Distortion measurement range: any fundamental frequency, 5 Hz to 600 kHz. Distortion levels of 0.1%-100% are measured full scale in 7 ranges.

Distortion measurement accuracy

Harmonic measurement accuracy (full scale)

Fundamental Input Less Than 30 V			
Range	±3%	±6%	±12%
100% - 0.3%	10 Hz - 1 MHz	10 Hz - 3 MHz	
0.1%	30 Hz - 300 kHz	20 Hz - 500 kHz	10 Hz - 1.2 MHz
Fundamental Input Greater Than 30 V			
Range	±3%	±6%	±12%
100% - 0.3%	10 Hz - 300 kHz	10 Hz - 500 kHz	10 Hz - 3 MHz
0.1%	30 Hz - 300 kHz	20 Hz - 500 kHz	10 Hz - 1.2 MHz

Elimination characteristics

Fundamental rejection: >80 dB.

Second harmonic accuracy for a fundamental of:
5 to 20 Hz: better than +1 dB.
20 Hz to 20 kHz: better than ±0.6 dB.
20 kHz to 100 kHz: better than —1 dB.
100 kHz to 300 kHz: better than —2 dB.
300 kHz to 600 kHz: better than —3 dB.

Distortion introduced in instrument: <0.03% from 5 Hz to 200 kHz; <0.06% from 200 kHz to 600 kHz.

Meter indication is proportional to the average value of a sine wave.

Frequency calibration accuracy
Better than ±5% from 5 Hz to 300 kHz.
Better than ±10% from 300 kHz to 600 kHz.

Input impedance: distortion mode: 1 MΩ ±5% shunted by less than 70 (*90) pF (10 MΩ shunted by <10 pF with HP 10001A 10:1 Divider Probe).

Voltmeter mode: 1 MΩ ±5% shunted by <35 pF 1 to 300 V rms; 1 MΩ ±5% shunted by <70 pF, 300 μV to 0.3 V rms.

Input level for distortion measurements: 0.3 V rms for 100% set level or 0.245 V for 0 dB set level (up to 300 V may be attenuated to set-level reference).

DC isolation: signal ground may be ±400 V dc from external chassis.

Voltmeter range: 300 μV to 300 V rms full scale (13 ranges) 10 dB per range.

Voltmeter accuracy (using front panel input terminals)

Range	±2%	±6%
300 μV	30 Hz - 300 kHz	20 Hz - 500 kHz
1 mV - 30 V	10 Hz - 1 MHz	5 Hz - 3 MHz
100 V - 300 V	10 Hz - 300 kHz	5 Hz - 500 kHz

Noise measurements: voltmeter residual noise on the 300 μV range <25 μV rms, when terminated in 600Ω (shielded), <30 μV rms terminated with a shielded 100 kΩ resistor.

Output: 0.1 ±0.01 V rms open circuit and 0.05 ±0.005 V rms into 2 kΩ for full scale meter deflections.

Output impedance: 2 kΩ.

Power supply: 115 or 230 V ±10%, 50 to 400 Hz, approximately 4 W. Terminals are provided for external battery supply. Positive and negative voltages between 30 V and 50 V are required. Current drain from each supply is 40 mA.

Model 332A

(Same as Model 331A except as indicated below.)

AM detector: high impedance dc restoring peak detector with semiconductor diode operates from 550 kHz to greater than 65 MHz. Broadband input, no tuning is required.

Maximum input: 40 V p-p or 40 V peak transient.

Distortion introduced by detector: carrier frequency: 550 kHz - 1.6 MHz; <50 dB (0.3%) for 3-8 V rms carriers modulated 30%. 1.6 MHz - 65 MHz: <40 dB (1%) for 3-8 V rms carriers modulated 30%.

NOTE: distortion introduced at carrier levels as low as 1 V is normally <40 dB (1%) 550 kHz to 65 MHz for carriers modulated 30%.

332A Option H05: same as 332A except low-pass filter is added (four-pole, 3 dB down at 30 kHz); meter reads in dBm.

Model 333A

(Same as Model 331A except as indicated below.)

Automatic nulling mode

Set level: at least 0.2 V rms.

Frequency ranges: X1, manual null tuned to <3% of set level; total frequency hold-in ±0.5% about true manual null. X10 through X10 k, manual null tuned to <10% of set level; total frequency hold-in ±1% about true manual null.

Automatic null accuracy: 5 Hz to 100 Hz; meter reading within 0 to +3 dB of manual null. 100 Hz to 600 kHz; meter reading within 0 to +1.5 dB of manual null.

High-pass filter: 3 dB point at 400 Hz with 18 dB per octave roll off. 60 Hz rejection >40 dB. Normally used only with fundamental frequencies greater than 1 kHz.

Power supply: same as Model 331A except current drain from each supply is 80 mA.

Model 334A

(Same as Model 333A except includes AM Detector described under Model 332A.)

334A Option H05: same as 334A except a low-pass filter is substituted for the high-pass filter; meter reads in dBm.

General

Weight: net, 17¾ lbs (8 kg); shipping, 26 lbs (11,8 kg).

Dimensions: 16¾" wide, 5" high (without removable feet), 13¼" deep (426 x 126 x 337 mm).

Accessories furnished: rack mounting kit for 19" rack.

Price: HP 331A, $680; HP 332A, $710; HP 333A, $920; HP 334A, $950; 332A Option H05, add $110; 334A Option H05, add $85; Option 001, indicating meter has VU characteristics conforming to FCC requirements for AM/FM and TV broadcasting, add $15.

GENERAL INFORMATION

What is a wave analyzer?

Wave Analyzer, Frequency Selective Voltmeter, Carrier Frequency Voltmeter, Tuned Voltmeter . . . they're all the same thing, just different names.

A wave analyzer can be thought of as a finite bandwidth window filter which can be tuned throughout a particular frequency range.

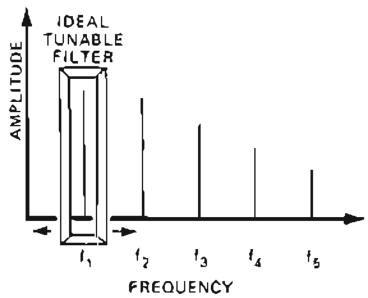


Figure 1. Wave analyzer tunable filter.

Signals located on the frequency spectrum will be selectively measured as they are framed by the window. Thus, for a particular signal, the wave analyzer can indicate its frequency (window position) and amplitude. Amplitude is read on an analog meter; frequency is read on either a mechanical or electronic readout. It has the advantage of accuracy, resolution, ease of operation and low cost.

The uses of wave analyzers can be categorized into three broad areas: 1) amplitude measurement of a single component of a complex frequency spectrum, 2) amplitude measurement in the presence of noise and interfering signals and, 3) measurement of signal energy appearing in a specified, well defined bandwidth.

Time-to-frequency domain conversion

The primary difference between wave analyzers and oscilloscopes is that the analyzers present information in the frequency domain while oscilloscopes display in the time domain. Since most information can be displayed in either domain, the user must decide which presentation is most meaningful for his application. As an example, when looking at an amplitude-modulated signal on an oscilloscope, it is difficult to extract frequency and amplitude information about the carrier and sidebands. But by using a wave analyzer, carrier and sideband information can be accurately and clearly obtained, as seen in Figure 2.

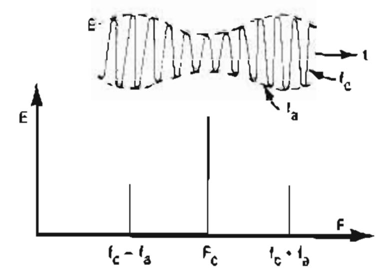


Figure 2. Carrier and sideband information can be accurately and clearly obtained by using a wave analyzer.

Wave analyzer considerations

Frequency characteristics

Range: should be selected with the future in mind as well as present requirements.

Accuracy and resolution: should be consistent with available bandwidths. Narrow bandwidths require frequency dial accuracy to place the narrow window in the proper position for measurement. Accuracy of instruments with selectable bandwidths is determined by the basic center frequency accuracy of the IF bandwidth filters in addition to the local oscillator frequency accuracy. Accuracy is usually specified as a fixed frequency error at any point on the dial meaning poorer percentage accuracy at the low frequency settings.

Readout: usually a frequency dial but newer instruments use a frequency counter as a dial. Although digital readout is more expensive, its accuracy and ease of use outweigh the increased cost.

Stability: frequency stability is important when using narrow bandwidths and for long term signal monitoring. Stability is achieved by phase locking and frequency counters, but the best stability is with automatic frequency control (AFC). AFC locks the local oscillator to the incoming signal and eliminates any relative drift between the two. It serves as a tuning aid to pull the signal to within the passband eliminating peaking the frequency control. The AFC always tunes within the passband improving accuracy on repetitive measurements.

Sweep: some instruments are equipped with a sweep arrangement to allow use as a spectrum analyzer. Readout is a CRT or X-Y recorder. Some instruments sweep the local oscillator while others use an external spectrum analyzer to sweep a broadband IF.

Amplitude characteristics

Range: the amplitude range is determined by the input attenuator and the internal noise of the instrument. Sensitivity is defined as the lowest measurable signal level equal to the noise level for a unity signal-to-noise ratio (often called tangential sensitivity). Sensitivity will vary with bandwidth and input impedance.

Dynamic range: defined as the dB ratio of the largest and smallest signals that can be simultaneously accommodated without causing an error in the measurement of the smaller.

Attenuators: the amplitude range switch is an attenuator in the input and IF stages. Instruments are available with a single control which switches input and IF range in predetermined steps or with two switches for independent control of input and IF range. Intermodulation distortion is lowest when the input amplifier has the minimum signal applied and the IF gain is greatest. Conversely the internal noise, important when making sensitive measurements, is lowest with maximum input signal and lowest IF gain. The two attenuator instruments allow this transfer of gain between input and IF to be accomplished easily.

Accuracy: amplitude accuracy is a function of frequency, input attenuator response, IF attenuator performance, calibration oscillator stability and accuracy, and meter tracking. Often specifications are broken up to separately describe each contributor.

Readout: amplitude readout is usually a meter calibrated in dB and/or volts. Linear voltage meters are used to allow the user to see down into the noise at the bottom of the scale. Digital readouts are not used because of their slow response and lack of directional and positional information. This is important since the readout is used as a tuning indicator to show presence of a signal in the passband and when it has reached a peak. Expanded scale meters allowing expansion of any 1 or 2 dB portion of the scale into a full scale presentation, allow resolution of input level changes of a few hundredths of a dB. This is useful when the wave analyzer is used as a sensitive indicator in bridge or comparison measurements. The expanded scale meter is included in some instruments and is an external accessory on others.

Input characteristics

Impedance: may be high impedance

bridging input of terminating impedance to match standard transmission lines. High frequency measurements require matched systems to avoid error-producing standing waves on interconnecting cables. The measure of impedance accuracy is usually return loss or reflection coefficient (RL = 20 log ρ). In lower frequency instruments, percent accuracy is used. High input impedance instruments are usually poorer in frequency and noise performance and are usually low frequency instruments. High impedance at high frequencies is accomplished by using a bridging probe to place the impedance at the point of measurement. The probe may be active with unity gain or passive with 20-30 dB insertion loss.

Input arrangement: input may be balanced-to-ground or unbalanced. Communications system usage typically requires balanced input. Standard 600 and 135/150Ω balanced inputs are limited in frequency to less than 1 MHz and 124Ω balanced to less than 10 MHz in most instruments. The impedance may be balanced to ground with the center point grounded or may be completely isolated from ground. Unbalanced inputs do not have frequency range limitations.

Typical application

Frequency response testing

With its BFO output, the wave analyzer is particularly useful for measuring filter and amplifier frequency responses. An alternative approach is to drive the device with a flat oscillator and measure its output with an accurate broadband voltmeter. However, this technique can lead to some very misleading results. If a notch filter is being measured, the rejection can only be as great as the largest distortion component of the driving signal. Reasoning shows that when the driving signal's fundamental is tuned to the notch center frequency, it will be filtered out, allowing all of its harmonics to be passed and measured.

A similar problem exists when trying to measure the response of a high-pass filter. The fundamental is again rejected while the harmonic distortion components are being passed and measured.

To be sure that the measurement will be accurate, Hewlett-Packard wave analyzers track and detect only its BFO output fundamental as it is tuned across its frequency range. The notch of the filter will then be accurately measured to its full depth.

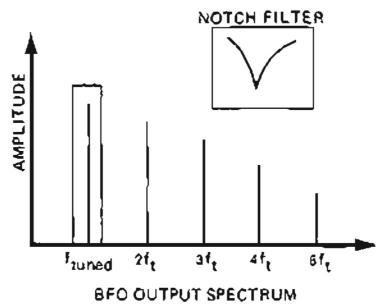


Figure 3. Only signal detected by wave analyzer. For example, the notch of a filter can be accurately measured to its full depth.

Table 1. HP wave analyzers.

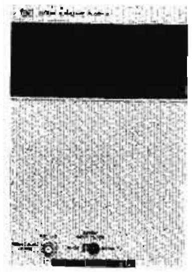
HP wave analyzers	Frequency range	Selective bandpasses	Dynamic range Absolute	Dynamic range Relative	Freq readouts	Type of inputs	Type of outputs	Modes of operation
302A (p. 448)	20 Hz to 50 kHz	6 Hz	30 μV–300 V full scale	>75 dB	dial	banana jacks	rec: 1 mA dc into 1000Ω full scale BFO: 2 V open circuit, meter at full scale	AFC, normal, BFO
3590A/ 3594A (p. 446)	20 Hz to 620 kHz	10 Hz 100 Hz 1000 Hz 3100 Hz	3 μV–30 V full scale	>85 dB	5-place digital	BNC unbalanced	rec: X and Y axes log and linear. BFO: to 1 V rms. L.O.: (1.28 MHz–1.9 MHz) 0.65 V rms.	AFC, restored, BFO, USB, LSB, AM sweep
310A (p. 449)	1 kHz to 1.5 MHz	200 Hz 1000 Hz 3000 Hz	10 μV–100 V full scale	>75 dB	dial	banana jacks	rec: 1 mA dc into 1500Ω full scale BFO: 0.5 V into 135Ω meter at full scale output impedance 135Ω	AFC, normal BFO, USB, LSB AM
312A/ 313* (p. 433)	1 kHz to 18 MHz 18 ranges	200 Hz 1000 Hz 3100 Hz	3 μV–3 V full scale or −97 to +23 dBm −107 to +13 dBm (600Ω only)	>72 dB	7-place decade counter	BNC & probe 11530A bridged/ terminated balanced or unbalanced	rec: 1 V dc full scale 1 kΩ source aux: 1 MHz (1 V p-p) 30 MHz (40–70 mV) rms L.O. (30–48 MHz) 60 to 90 mV rms audio: >0.5 V into 10 kΩ 313A: Track or tuned 75Ω unbalanced, −99.9 to +10 dBm	AFC, AM, beat LSB, USB
3591A/3594A (p. 435)	Same as 3590A/3594A except input bridged/terminated bal. or unbal. and modified input circuitry.							
312A/313A Op. H01 (p. 433)	Same as 312A except 1 kHz to 22 MHz and WE-477B input unbalanced.							
312A/313A Op. H05	Same as 312A Option H01 except 50Ω unbalanced input with BNC connector.							

*313A option 001, 50Ω unbalanced output.

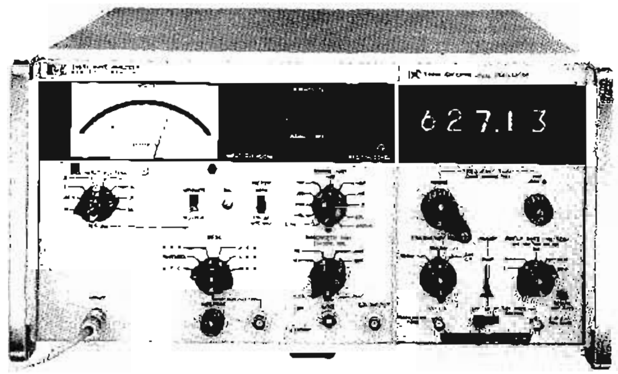
PLUG-IN WAVE ANALYZER

85 dB dynamic range; electronic sweeping

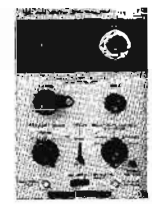
Models 3590A, 3592A, 3593A, 3594A, 3595A



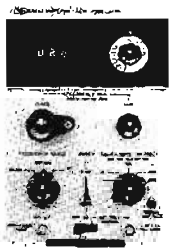
3592A



3590A/3594A



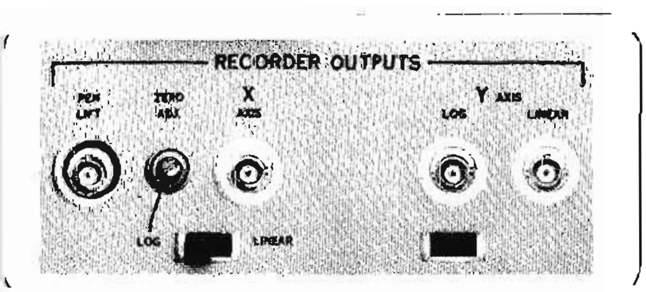
3595A



3593A

Description

The Hewlett-Packard Model 3590A Wave Analyzer offers automatic, state-of-the-art detection of signal amplitude and frequency information. Over a frequency range of 20 Hz to 620 kHz, the analyzer can separate frequency components of an input signal to locate the fundamental, harmonics, intermodulation products, or any other signals present in the spectrum. Selectable bandwidths of 10, 100, 1000 and 3100 Hz permit easy location of signals and separation of closely spaced components. Operation has been greatly simplified by automatic amplitude ranging and electronic sweeping. X-Y recorder outputs permit frequency spectrum recordings to be made covering the entire frequency range with a linear dB amplitude display of 90 dB.



Recorder outputs

Both X and Y recorder outputs are available at the rear panel of the 3590A. These outputs produce either logarithmically or linear varying dc voltages. Any combination of X and Y log or linear outputs (Lin-lin, lin-log, log-lin, or log-log) can be chosen to provide maximum flexibility. Recordings can also be made on standard semi-log graph paper to produce direct plots.

Y-axis log and linear outputs occur simultaneously, but the X-axis output is switched to choose the output function. When the switch is in LINEAR (RAMP ONLY), the dc offset produced by the start frequency location is blocked out. This permits wide expansion of a narrow sweep segment without having to buck out the offset voltage.

A contact closure drops the pen during the sweep. During retrace and standby, the pen is lifted.

Plug-ins

3592A Auxiliary Plug-in

The 3592A is made for the situation where two or more main frames are slave tuned. This situation occurs when two signals are to be analyzed simultaneously. An example of this is reading X and Y axis sensors in a vibration test. The other plug-ins can also be slave tuned.

3593A/4A/5A Sweeping Local Oscillator

The 3593A was designed for fast sweeping for short periods of time. It represents a price savings over the other sweeping plug-ins.

The 3594A has a nixie tube readout for accurate setting of start frequencies and readout of frequencies during sweep. The 5-digit readout represents an order of magnitude improvement in resolution over the mechanical readouts of the other plug-ins.

The 3595A was designed to fulfill the requirement of slow sweeping for long periods of time. Using the 2 Hz/s sweep speed the 3595A can sweep the entire audio spectrum (20 Hz-20,000 Hz) with a 10 Hz bandwidth. It is also possible to sweep a baseband signal from 312 kHz to 552 kHz with a 1000 Hz bandwidth. These longtime sweeps can be made automatically with no resetting or manual ranging.

Specifications

3590A Wave Analyzer

Frequency range: 20 Hz to 620 kHz.

Frequency accuracy: refer to plug-in specs.

Amplitude ranges: 3 μV to 30 V full scale in 16 ranges.

Amplitude accuracy (meter switch in normal position)

Overall accuracy: $\pm$0.5 dB or $\pm$5% of reading, including the following: frequency response flatness: $\pm$0.2 dB or $\pm$2% total deviation; meter tracking: $\pm$0.1 dB or $\pm$1% of reading, 0 dB to $-$10 dB indication.

Amplitude accuracy (meter switch in linear dB position)

Overall accuracy: ±1 dB; internal calibrator: frequency: 100 kHz ±10 Hz; amplitude: full scale on 0 dB range in CAL mode; amplitude accuracy: ±0.1 dB (±1%) with 90 day calibration cycle.

Dynamic range (IM and harmonic distortion products)

>85 dB below zero dB reference level when ABSOLUTE measurements are being made (>70 dB for 20 Hz to 50 Hz). >80 dB below zero dB reference level when RELATIVE adjustment is used (>70 dB for 20 Hz to 50 Hz); (residual responses): >80 dB below zero reference (>70 dB for 20 Hz to 50 Hz).

Noise level (on .01V max input voltage range at 20 kHz)

Bandwidths	Input Noise Level (600Ω Source Impedance)
10 Hz and 100 Hz	<0.3 μV or at least 90 dB below 0 dB reference
1 kHz and 3.1 kHz	<1.0 μV or at least 80 dB below 0 dB reference

Selectivity (shape factor)

	Bandwidths			
Rejection	10 Hz	100 Hz	1 kHz	3.1 kHz
−3 dB Point	10 Hz	100 Hz	1 kHz	3.1 kHz
−60 dB Point	35 Hz	320 Hz	3.1 kHz	9.6 kHz

(Frequency accuracy at -3 dB and -60 ±10%)

Automatic frequency control: capture threshold: 75 dB below 0 dB reference, AFC will lock on trace signal; dynamic hold-in range: >3 bandwidths. Tracking rate proportional to bandwidth.

Input impedance

Resistance: 100 kΩ all ranges.

Capacitance: <50 pF for 10 mV, 30 mV ranges <30 pF for 100 mV to 30 V ranges.

Automatic ranging: 8 ranges, 0 dB to −70 db. Ranging rate proportional to bandwidth.

Mode outputs: amplitude: adjustable 0 to 1 V rms open circuit; BFO frequency flatness: ±0.2 dB or ±2%; resistance: 600Ω, BFO frequency is equal to tuned frequency.

L.O. output

Frequency: 1.28 MHz to 1.90 MHz (1.28 MHz + tuned frequency); amplitude: 0.65 V rms ±20% open circuit; resistance: 250Ω.

Recorder outputs

X-Axis (3593A/3594A only)	Plug-in Frequency Ranges 62 kHz	620 kHz
X-axis linear output: (1 kΩ source resistance)	0 to -12.4 V (200 mV/kHz ±5%)	0 to -12.4 V (20 mV/kHz ±5%)
X-axis log output: (1 kΩ source resistance)	5 V/decade ±5% (20 Hz - 62 Hz)	5 V/decade ±5% (500Hz - 620kHz)

Y-axis: linear Y axis output: +5 V dc ±4% for full scale meter indication, 2.5 kΩ source resistance; log Y axis output: +1 V to +10 V dc, ±0.1 V proportional to linear dB meter indication (−90 to 0 dB, 0.1 V/dB) 1 kΩ source resistance.

Pen lift: contact closure during sweep, open during reset (3593A/3594A only).

Power: 115 V or 230 V ±10%, 48 Hz to 440 Hz, 115 VA (includes plug-in).

Dimensions: 16¾" wide, 8¾" high, 16⅜" deep (425 x 221 x 416 mm).

Weight: net 38 lbs (17,2 kg); shipping, 55 lbs (24,9 kg).

Accessories furnished: rack mounting kit for 19" rack.

Price: HP 3590A, $3280.

Specifications

Model 3592A Auxiliary Plug-in

External L.O. Input: 0.65 V ±0.2 V rms, 1.28 to 1.90 MHz (1.28 MHz + tuned frequency).

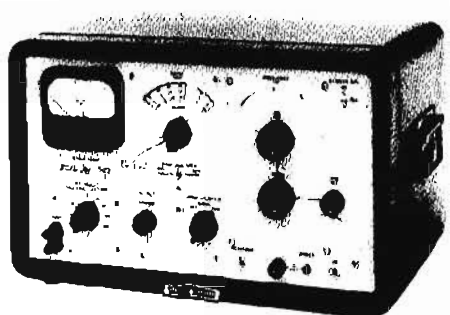
Weight: net, 2 lbs (.9 kg); shipping, 6 lbs (2,7 kg).

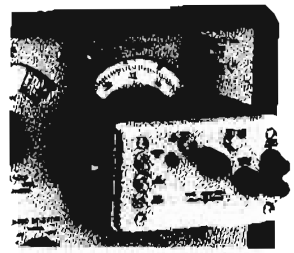
Dimensions: 8" high, 4.5" wide, 11" deep (20 x 11 x 28 cm).

Price: HP 3592A, $80.

	MODELS 3593A and 3594A		MODEL 3595A	
Ranges:	20 Hz to 62 kHz	500 Hz to 620 kHz	20 Hz to 62 kHz	500 Hz to 620 kHz
Frequency Accuracy:	3593A: ±(1% + 20 Hz) of dial setting 3594A: ±(1 Hz + time base accuracy)	3593A: ±(1% + 200 Hz) of dial setting 3594A: ±(10 Hz + time base accuracy)	±(1% + 20 Hz) of dial setting	±(1% + 200 Hz) of dial setting
Frequency Resolution:	3593A: 10Hz/minor div. 3594A: 1Hz/minor div.	3593A: 100Hz/minor div. 3594A: 10Hz/minor div.	10 Hz/minor div.	100 Hz/minor div.
Ext. Freq. Control:	0 to 15.5 V (250 mV/kHz ±5%)	0 to 15.5 V (25 mV/kHz ±5%)	0 to 15.5 V (250 mV/kHz ±5%)	0 to 15.5 V (25 mV/kHz ±5%)
Bandwidth Specified:	10, 100, 1000 3100 Hz	100, 1000, 3100 Hz	10, 100, 1000 3100 Hz	100, 1000, 3100 Hz
X-axis Recorder Output:	Linear output: 0 to −12.4 V			
	200 mV/kHz ± 5%	20 mV/kHz ± 5%	Same as 3593A/94A	
	Log output: 5 V/decade ± 5%			
	50 Hz calib. point	500 Hz calib. point	20 Hz calib. point	200 Hz calib. point
Y-axis:	Refer to main frame specifications			
Sweep Rates:	1, 10, 100, 1000, 3100 Hz/s.		1, 2, 10, 100, 1000 Hz/s.	
Sweep Ramp Linearity:	± 1% of final value		±2.5% of final value for first 10,000 s.	
Max Sweep Time:	620 s ± 15%		60,000 s.	
Start Freq:	determined by frequency setting			
Pen Lift:	contact closure during sweep, open during reset.			
External L.O. Output:	0.65 V ±0.2 V rms, 1.28 to 1.90 MHz (1.28 MHz + tuned frequency).			
Dimensions:	8" high, 4.6" wide, 11" deep (20 x 11 x 28 cm).			
Weight:	net 7.5 lbs (3,4 kg); shipping 12 lbs (5,5 kg).		net 9.5 lbs. (4,3kg); shipping 14 lbs. (6,3 kg)	
Price:	HP 3593A, $1130; HP 3594A, $1640.		HP 3595A, $1250	

WAVE ANALYZER, SWEEP DRIVE
Measures wave components with narrow B.W.
Models 302A, 297A


302A


297A mounted on 302A

Description

The Model 302A Wave Analyzer separates a complex input signal into individual frequency components such as harmonic, intermodulation products, and other spectral components. By tuning the 302A across the spectrum, the components can be individually measured and evaluated. Frequency is read in Hz from the dial, and amplitude is read in volts, percent or dB from the meter.

The 302A is also an oscillator-tuned voltmeter combination. This feature is particularly useful for measuring input-output characteristics of filters, amplifiers, and active devices. The oscillator output (BFO) and the analyzer's input tuning track together over the entire range of 20 Hz to 50 kHz and is controlled by the tuning dial. Because one control tunes both the oscillator output and the analyzer input simultaneously, one-step response measurements are made simply, quickly and conveniently. And, since the analyzer has a very narrow bandpass, any signal distortion has negligible effect on the meter reading, making measurements highly accurate even at very low levels.

Specifications, 302A

Frequency range: 20 Hz to 50 kHz.
Frequency accuracy: ±(1% +5 Hz).
Frequency resolution: 10 Hz per division.
Amplitude ranges: 30 μV to 300 V full scale in 15 ranges.
Amplitude accuracy: ±5% of full scale.
Internal level calibrator
- **Amplitude accuracy:** ±2%.
- **Amplitude:** 1 V full scale.
- **Frequency:** 5 kHz ±1 kHz.

Dynamic range
- **IM and harmonic distortion products:** >75 dB below 0 dB reference.
- **Residual responses:** >75 dB below 0 dB reference.

Selectivity

Rejection	Bandwidth
0.1 dB	>2 Hz
3 dB	7 Hz ± 10%
60 dB	60 Hz ± 10%
80 dB	140 Hz ± 10%

Input impedance
- **Resistance:** 30 μV to 1 mV input ranges, 100 kΩ; 3 mV to 300 V input ranges, 1 MΩ.
- **Capacitance:** 30 μV to 1 mV input ranges, <100 pF; 3 mV to 300 V input ranges, <20 pF.

Mode outputs
- **AFC and NORMAL outputs:** 0 to 2 V rms open circuit proportional to meter deflection. Frequency is exactly the same as the measured component's frequency.
- **AFC hold-in range:** >±100 Hz.
- **BFO:** constant-level amplitude, adjustable 0 to 2 V rms open circuit. Output frequency tracks the tuned frequency.
- **Frequency response flatness:** ±2%.
- **Source resistance:** 600Ω.

Recorder output: 1 V open circuit; source resistance, 1 kΩ.
Power: 115 or 230 V ±10%, 48 to 440 Hz, approx. 10 VA; terminals are provided for powering instrument from external battery source; battery supply range, 28 V to 18 V.
Dimensions: cabinet 20¾" wide, 12½" high, 14½" deep behind panel (527 x 318 x 368 mm).
Weight: cabinet: net, 43 lbs (19,5 kg); shipping, 51 lbs (23 kg); rack mount: net, 35 lbs (16 kg); shipping, 49 lbs (22,1 kg).
Price: HP 302A (cabinet), $2195.
HP 302AR (rack mount), $2180

Sweep tuning

Hewlett-Packard Models 302A, 310A or 312A Wave Analyzers can be swept through all or any part of their ranges with the HP Model 297A Sweep Drive. The 297A, which attaches to the front panel of the analyzer, drives the frequency control at either 17 or 170 Hz per second. This instrument also provides an output voltage proportional to the sweep which, in conjunction with the recorder output from the analyzer, permits automatic plots of amplitude vs. frequency on an X-Y recorder.

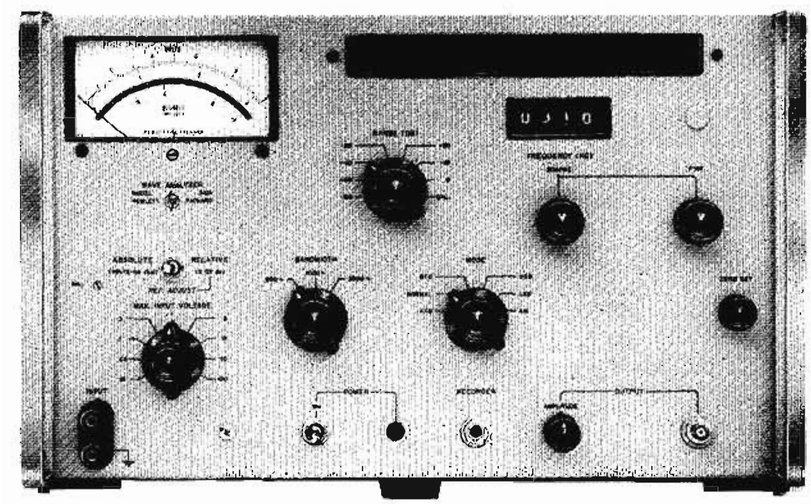
Specifications, 297A

Sweep limits: any interval from 64 revolutions to 10°.
Sweep speed with 302A: 170 and 17 Hz/s.
Shaft speed: 10 rpm, 1 rpm, and neutral; other shaft speeds available on special order; neutral permits manual operation.
Sweep voltage output: at least 12 V maximum; full output is obtained with either 2.1 or 50 rpm of the shaft.
Torque: 9 in/oz at 10 rpm (approx. 22 in/oz max. at 1 rpm).
Power: 115 V ±10%, 60 Hz, 40 VA running or stalled.
Weight: net, 4¼ lbs (1,9 kg); shipping, 7 lbs (3,2 kg).
Price: HP 297A, $445.
HP 297A option H03, power: 230 V, 50 Hz.

WAVE ANALYZER

Measure harmonics, intermodulation products

Model 310A



310A

Description

Model 310A High Frequency Wave Analyzer separates the various frequency components of an input signal so that the fundamental, harmonics, or intermodulation products can be determined and analyzed. Any signal component between 1 kHz and 1.5 MHz may be selected for measurement. Model 310A also functions as an efficient tuned voltmeter for accurately measuring relative or absolute signal levels, as a signal source for selective response measurements, and as either an AM receiver or carrier insertion oscillator for demodulating single sideband signals.

Specifications

Frequency range: 1 kHz to 1.5 MHz (200 Hz bandwidth); 5 kHz to 1.5 MHz (1000 Hz bandwidth); 10 kHz to 1.5 MHz (3000 Hz bandwidth).

Frequency accuracy: ±(1% + 300 Hz).

Frequency scale: linear graduation, 1 div per 200 Hz.

Selectivity: 3 IF bandwidths, 200 Hz, 1000 Hz and 3000 Hz, mid-point of the passband (f_o) is readily distinguished by a rejection region 1 Hz wide between the 3 dB points.

	200 Hz bandwidth	1000 Hz bandwidth	3000 Hz bandwidth
Rejection*	frequency (Hz)	frequency (Hz)	frequency (Hz)
≥3 dB	$f_0 \pm 108$	$f_0 \pm 540$	$f_0 \pm 1550$
≥50 dB	$f_0 \pm 500$	$f_0 \pm 2400$	$f_0 \pm 7000$
≥75 dB	$f_0 \pm 1000$	$f_0 \pm 5000$	$f_0 \pm 17000$

*Rejection increases smoothly beyond the −75 dB points.

Voltage range: 10 μV to 100 V full scale, ranges provided by input attenuator and meter range switch in steps of 1:3 or 10 dB.

Voltage accuracy: ±6% of full scale.

Internal calibrator stability: ±1% of full scale.

Dynamic range: >75 dB.

Noise and spurious response: at least 75 dB below a full-scale reference set on the 0 dB position of Range switch.

Input resistance: determined by input attenuator; 10 kΩ on most sensitive range, 30 kΩ on next range, 100 kΩ on other ranges; shunt capacitance <100 pF on three most sensitive ranges, <50 pF on other ranges.

Automatic frequency control: dynamic hold-in range is ±3 kHz minimum at 100 kHz; tracking speed is approximately 100 Hz/s; locks on signal as low as 70 dB below a full-scale reference set on the 0 dB position of the Range switch.

Restored-frequency output: restored signal frequency maximum output is at least 0.25 V (meter at full scale) across 135Ω, with approximately 30 dB of level control provided; output impedance approximately 135Ω.

BFO output: 0.5 V across 135Ω with approx. 30 dB of level control provided; output impedance approx. 135Ω.

Recorder output: 1 V dc into an open circuit from 1000Ω source impedance for single-ended recorders; output of 1 mA dc into 1500Ω or less available on special order.

Receiver function (Aural or Recording provision): internal carrier reinsertion oscillator is provided for demodulation of either normal or inverted single sideband signals; AM signal also can be detected.

RFI: conducted and radiated leakage limits are below those specified in MIL-I-6181D.

Power: 115 or 230 V ±10%, 50 to 400 Hz; 20.5 W max.

Dimensions: 16¾" wide, 10¾" high, 18⅜" deep (426 x 274 x 467 mm); hardware furnished for conversion to rack mount 19" wide, 10-15/32" high, 16⅜" deep behind panel (483 x 266 x 416 mm).

Weight: net 45 lbs (20,3 kg); shipping 52 lbs (23,4 kg).

Accessories available: 11001A Cable Assembly, $13; 10503A Cable Assembly, $13; 10111A Adapter, $10; 297A Sweep Drive, $445; 11505A Bench Stand for 297A, $25.

Price: HP 310A, $2835.

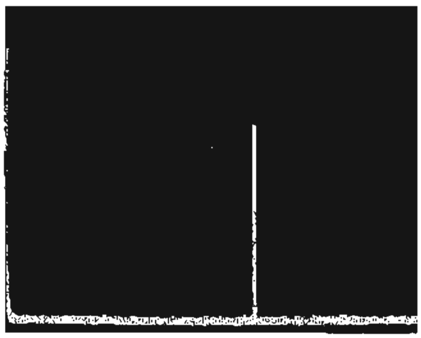
Options

001: internal frequency calibrator providing check points every 100 kHz; interpolation accuracy (between check points): ±2 kHz up to 1.4 MHz, ±3 kHz between 1.4 and 1.5 MHz; add $110.

002: dB scale uppermost on meter face and extended to −25 dB; add $30.

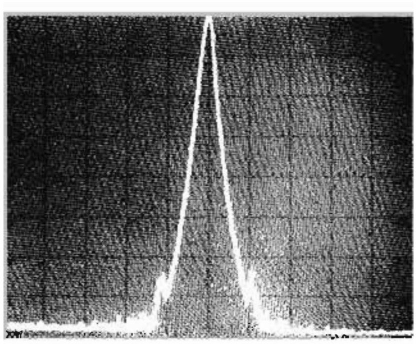
Spectrum Analyzers

Basically a spectrum analyzer is a swept receiver that provides a CRT display of amplitude versus frequency. It shows how energy is distributed as a function of frequency, displaying the Fourier components of a given waveform. With it you can measure frequency response; characterize mixers, doublers, and other frequency conversion devices. You can measure signal purity or see directly the bandwidth needed to pass a given signal.



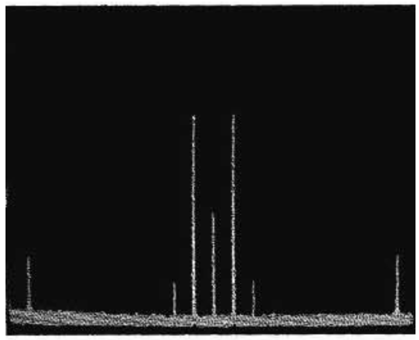
CW Signal. This is a calibrated display of a -30 dBm CW signal at 60 MHz. The zero frequency indicator appears at the far left of the display; the horizontal scan is 10 MHz/div. The log reference level (top graticule line of the display) is 0 dBm.

Oscillators



Oscillator spectral purity. The spectrum analyzer may be used to measure the spectral purity of oscillators. Above, a 70 MHz carrier has line related sidebands (60 Hz) which are 65 dB down. These sidebands may be the result of ripple on the power supply. The spectrum analyzer scan is 50 Hz per division, and a 10 Hz bandwidth was used to allow resolution of the close in sidebands.

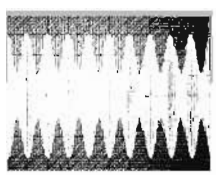
Frequency converters



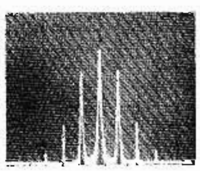
Mixer. Driving a double-balanced mixer with an L.O. of 50 MHz at 0 dBm and with a 5 MHz, -30 dBm signal, results in the output shown. The log reference level is -10 dBm and the frequency scan is 10 MHz division centered at 50 MHz. The two sidebands at 45 MHz and 55 MHz have a conversion loss of 6 dB (6 dB below the -30 dBm graticule line). The local oscillator (50 MHz signal) has 50 dB isolation. 5 MHz signal leak-through is at -71 dBm, i.e., 41 dB isolation. Second order distortion products at 40 and 60 MHz are 40 dB down.

Modulators

A



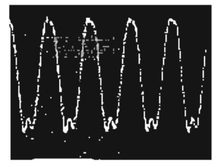
B



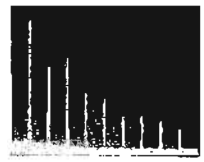
50 percent AM. Figure A shows a time domain photograph of an amplitude modulated carrier. The percent modulation is: $M = (6-2)/(6+2) = 4/8 = 50\%$. (Scope calibration 0.1 msec/division, 50 mV/division.) The same waveform is measured in the frequency domain in "B" since the carrier and sidebands differ by 12 dB, $M = 50\%$. Frequency scan is 10 kHz/div centered at 60 MHz, and the log reference level is $+10$ dBm. You can also measure the 2nd and 3rd harmonic distortion on this waveform. 2nd harmonic sidebands at $f_c \pm 2 f_m$ are 28 dB down.

Amplifiers

A

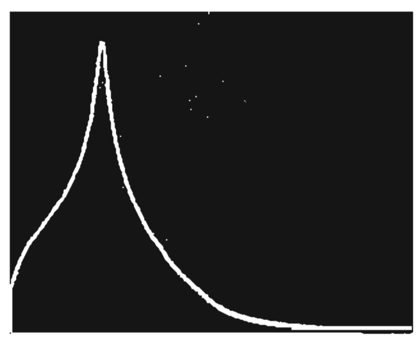


B



Harmonic distortion. Overdriving an amplifier results in a severely distorted waveform easily observed with the oscilloscope; however, quantitative measurements of distortion levels are difficult to obtain. The scope calibration is 0.05 volt/division vertical, 0.1 μsec/division horizontal. The spectrum analyzer easily gives quantitative information about the distortion of the two signals. The frequency scale is 5 MHz/division centered at 25 MHz, and the log reference level is 0 dBm.

Filters



Filter frequency response. Using a tracking signal source and a spectrum analyzer, filter frequency response is easily measured and recorded. In this case, an audio filter used in a communications system is being measured. The spectrum analyzer scan is 0 to 10 kHz. The log reference level is -10 dBV, and the input to the filter was at -13 dBV. Therefore, the insertion loss at 2.4 kHz is 4 dB. Extremely high-Q devices can be measured with this system.

Spectrum Analyzer Capabilities

To be useful in making measurements in the frequency domain, the analyzer must be capable of making quantitative measurements. To make quantitative measurements, an analyzer must:

1) make absolute frequency measurements
2) make absolute amplitude measurements
3) operate over a large dynamic range
4) have frequency and amplitude high resolution capability
5) have high sensitivity
6) provide means of observing signals at the slow sweep rate high resolution scans i.e. variable persistence.

Hewlett-Packard spectrum analyzers excel in these six measures of performance.

Let us consider each of these performance standards in greater detail.

Absolute frequency measurements

There are two ways to measure absolute frequency with an Hewlett-Packard spectrum analyzer. The absolute frequency can be read off the slide-rule type of frequency dial. Accuracy in this case is approximately 1% of full scale. It is also possible to use a counter and tracking generator to measure the frequency of signals on the CRT to much better accuracy.

The tracking generator is a source that tracks the spectrum analyzer tuning response. Hence, the tracking generator frequency is equal to the frequency the spectrum analyzer is tuned to. Counting the tracking generator frequency results in precision frequency measurements.

Absolute amplitude measurements

All Hewlett-Packard spectrum analyzers are absolutely calibrated for amplitude measurements. This means the spectrum analyzer indicates to the user what the log ref level or linear sensitivity is regardless of control settings. In addition, a warning light is available to signal any combination of control settings that leads to an uncalibrated condition. This makes operation of the analyzer easy and foolproof.

Dynamic range

The dynamic range of a spectrum analyzer is defined as the difference between the input signal level and the average noise level or distortion products whichever is greater. Hence, dynamic range can be either distortion limited or noise limited.

Frequency and amplitude resolution

Frequency resolution is the ability of the analyzer to separate signals closely spaced in frequency. The frequency resolution of an analyzer is a function of three factors:

1) minimum IF bandwidth
2) IF filter factor
3) spectrum analyzer stability

The minimum IF bandwidth ranges from 10 Hz to 300 Hz on Hewlett-Packard spectrum analyzers.

IF filter factor is the ratio of 3 dB bandwidth to 60 dB bandwidth. Filter factor specifies the selectivity of the IF filter. Hewlett-Packard spectrum analyzers have IF filter factors as low as 11:1.

Analyzer frequency stability also limits resolution. The residual FM (short term stability) should be less than the narrowest IF bandwidth. If not, the signal would drift in and out of the IF pass band. Hewlett-Packard analyzers have excellent stability. The residual FM ranges from <1 Hz at low frequency, to <100 Hz at microwave frequencies. The stabilization circuitry is completely automatic and foolproof. No signal recentering, phase-lock loop manual search, or checking is required.

Amplitude resolution is a function of the vertical scale calibration. Hewlett-Packard analyzers offer both log calibration for observing large amplitude variations (10 dB/div and 2 dB/div) and linear calibration for observing small amplitude variations.

Sensitivity

Sensitivity is a measure of an analyzer's ability to detect small signals, and is often defined as the point where the signal level is equal to the noise level. Since noise level decreases as the bandwidth is decreased, sensitivity is a function of bandwidth. The maximum attainable sensitivity ranges from −140 dBm to −125 dBm with Hewlett-Packard analyzers.

Variable persistence

High resolution and sensitivity both require narrow bandwidths and consequently slow sweep rates. Because of these slow sweeps, variable persistence is virtually indispensable in providing a bright, steady, flicker-free trace. (In effect, variable persistence allows one to vary the length of time a trace remains on the CRT.)

Tracking preselector

Spurious responses are generated when the analyzer is over-driven. In addition if an analyzer utilizes harmonic mixing, multiple and image responses can occur.

The only way to simultaneously avoid spurious, multiple, harmonic and image responses, is to filter the RF signal through a tracking preselector. This is an electronically tuned bandpass filter that automatically tracks the analyzer's tuning. A preselector improves the dynamic range of the analyzer from 70 dB to 100 dB.

Tracking generator

A tracking generator is a tracking signal source which tracks the tuning response of a spectrum analyzer. The tracking generator expands the measurement capability of the spectrum analyzer.

A tracking generator/spectrum analyzer is ideal for frequency response and return loss measurements. Inserting a test device between the tracking generator and analyzer results in a display of the insertion loss versus frequency or frequency response of the device. Return loss measurements versus frequency are also possible with a directional coupler or hybrid. The tracking generator also makes precision frequency measurements possible as described in "Absolute Frequency Measurements" above. In addition, the tracking generator is an excellent stable sweeping signal generator. The residual FM ranges from ±1 Hz for low frequency tracking generators to ±400 Hz for microwave tracking generators.

Wave analyzers

Wave analyzers offer another method of measuring both the amplitude and frequency of an input signal's component. A wave analyzer is similar to a spectrum analyzer. However, the characteristics of a wave analyzer are optimized for low frequency narrow band measurements.

The electronic sweeping and amplitude autoranging of the new HP 3590A wave analyzer permit X-Y and strip chart plots of amplitude versus frequency over a frequency range of 20 Hz to 620 kHz and a dynamic range of more than 85 dB.

A BFO output is available with Hewlett-Packard wave analyzers. This output corresponds to a tracking generator output in a spectrum analyzer. With a BFO output swept frequency response measurements are possible.

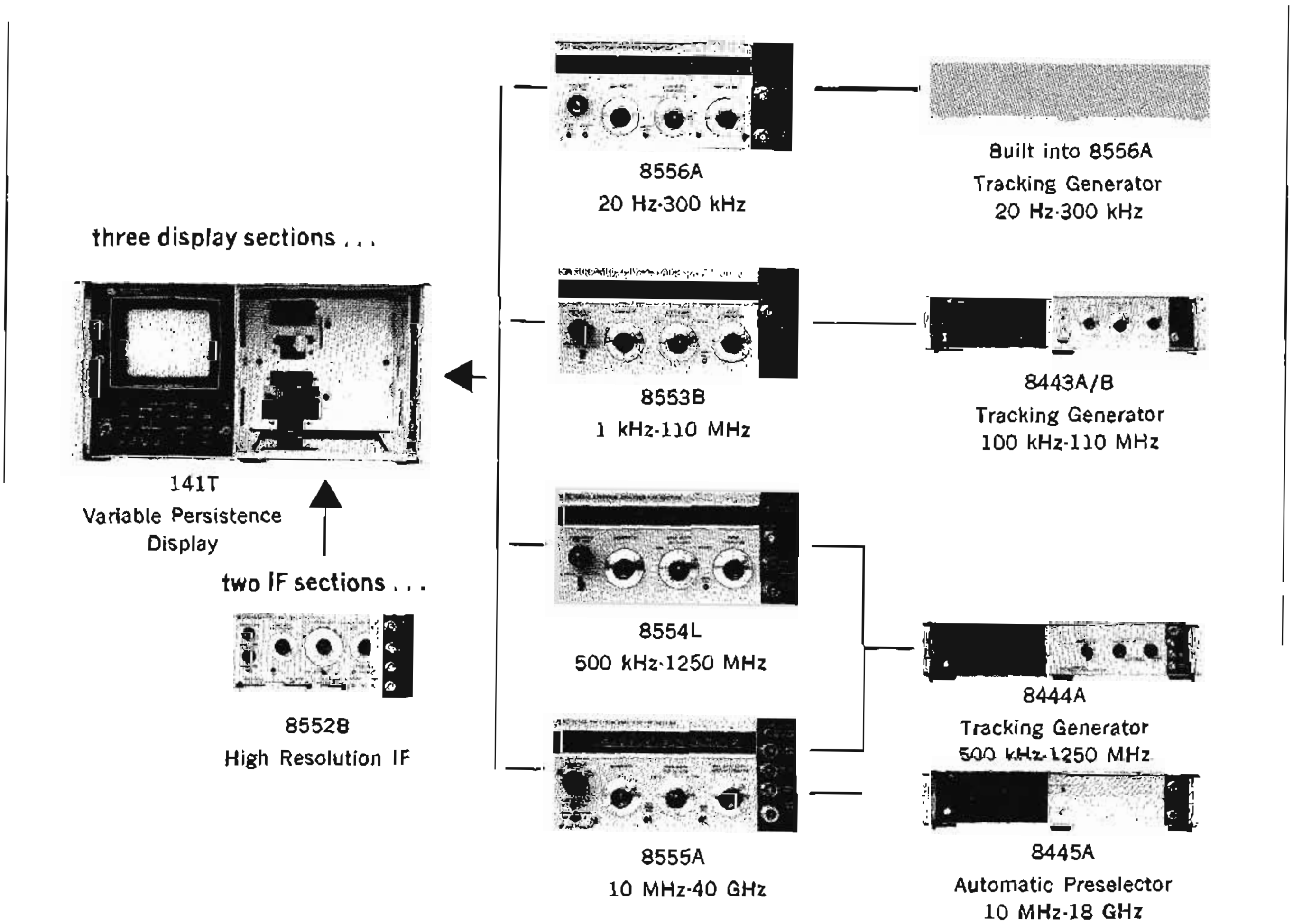
QUANTITATIVE SPECTRUM ANALYSIS
20 Hz to 40 GHz

The high value Spectrum Analyzer Family . . .

- Cover 20 Hz to 40 GHz with just a change of tuning section.
- Add measurement capability to your system as it is needed.
- Select a system from a wide choice of configurations.
- Enjoy the advantages of a fully calibrated solid state system.

Your Choice of . . .

tuning sections . . . **and companion instruments.**



The Family Features . . .

AUTOMATIC TUNING STABILIZATION for narrow scans means operating ease.

DIGITAL FREQUENCY READOUT with counter accuracy is available with the 8443A. Counter outputs are supplied with the other tracking generators.

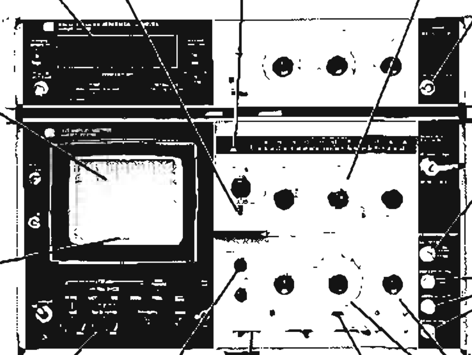
INTERNAL GRATICULE: Eliminates parallax reading errors which can contribute as much as 2 dB error to the signal amplitude reading.

A FREQUENCY MARKER helps the user select and identify the signal of interest. The FREQUENCY control positions the marker.

VARIABLE PERSISTENCE: Allows flicker-free slow scans. Slower scans are necessary when using the high resolution capability of today's analyzer.

MANUAL SCAN: *Allows the setting up of accessories such as X-Y recorders, adjusting signals on screen during slow scans, and measuring frequency with a counter.*

THE CALIBRATION WARNING LIGHT maintains absolute amplitude calibration by assuring the operator that the selected scan rate is not too fast for the bandwidth and video filtering chosen.



VIDEO FILTERING: Allows easier observation of weak signals, and makes wide band noise and EMI measurements easier.

THREE CALIBRATED SCAN MODES—Preset, Per Division, and Zero Scan. The analyzer can scan over its full frequency range, a given scan width, or operate as a fixed tuned receiver.

SWEPT FREQUENCY RESPONSE MEASUREMENTS over 120 dB dynamic range of filters, amplifiers, networks, etc., are possible with a tracking generator.

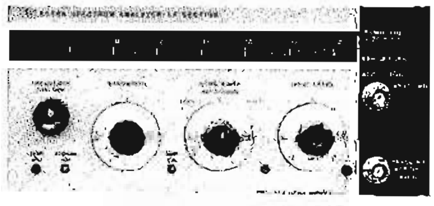
A very stable **INTERNAL CALIBRATION STANDARD** for initial calibration of the spectrum analyzer.

A FULL SET OF RECORDER OUTPUTS for full recorder compatibility.

ABSOLUTE AMPLITUDE CALIBRATION: Means the calibration of the CRT, i.e., log ref level or linear sensitivity, is always indicated by the analyzer regardless of control settings.

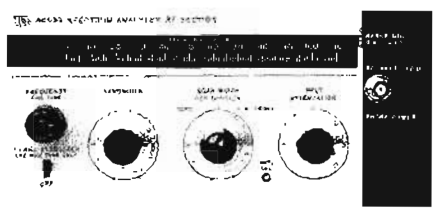
Versatility of **THREE DISPLAY MODES**—linear, 10 dB/div, and 2 dB/div. The 2 dB/div is particularly useful for frequency response measurements.

The Tuning Sections . . .



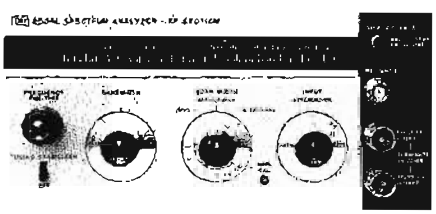
8556A—20 Hz to 300 kHz

- Absolute Amplitude Accuracy to ±0.6 dB.
- 20 Nanovolt Sensitivity (−142 dBm 50Ω).
- High Resolution 10 Hz Bandwidth <1 Hz Residual FM (with 8552B).
- Selectable Scan Widths—Preset from 0 or Symmetrical About Center Frequency.
- Built-in 0.01% Crystal Markers for Frequency Accuracy.
- Two Frequency Scales Selectable (0-30 kHz, 0-300 kHz)
- Fully Isolated High Impedance Input Useful with Compensated. Oscilloscope Probes.
- Built-in Tracking Generator for Swept Frequency Response. Measurements Over 120 dB Range.
- Counter Output for Precision Frequency Measurements.
- Price: $1,690.



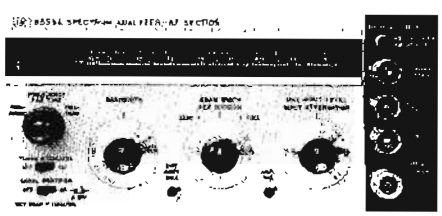
8553B—1 kHz to 110 MHz

- Absolute Amplitude Accuracy to ±0.8 dB.
- Maximum Sensitivity —140 dBm (10 Hz Bandwidth).
- 10 Hz Resolution to See 60 Hz Sidebands 60 dB Down (with 8552B).
- Scan Widths from 200 Hz to 100 MHz.
- Frequency Accuracy ±10 Hz with Tracking Generator.
- Two Frequency Scales Selectable (0-11 MHz, 0-110 MHz).
- Probe Power Provided for Use with High Impedance Active Probes.
- All Distortion Products 70 dB Down with —40 dBm to Mixer.
- Price: $2,275.



8554L—500 kHz to 1250 MHz

- Absolute Amplitude Accuracy to ±1.6 dB.
- Sensitivity to —117 dBm (300 Hz Bandwidth).
- Residual FM Less Than 300 Hz.
- Scan Widths from 20 kHz to 1250 MHz.
- Frequency Accuracy ±10 MHz.
- All Distortion Products 65 dB Down with —40 dBm to Mixer.
- Price: $3,500.



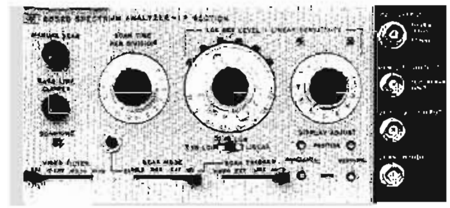
8555A—10 MHz to 40 GHz

- Absolute Amplitude Accuracy to ±1.6 dB.
- Direct Coax Input to 18 GHz.
- Maximum Sensitivity —125 dBm (Fundamental Mixing, 100 Hz Bandwidth).
- High Resolution 100 Hz Bandwidth (30 Hz First LO Residual FM).
- Full Scans of 2, 4, 6, and 8 GHz Free of Unwanted Responses with Preselection.
- Frequency Accuracy ±15 MHz (Fundamental Mixing).
- Price: $6,175.

The IF Sections

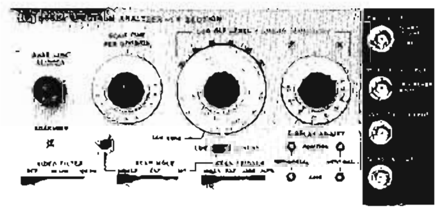
8552B—High Resolution

- 11:1 IF Filter Factor (5-Stage Crystal Filter).
- 10 Hz Minimum Bandwidth.
- 10 dB/Div Log, 2 dB/Div Log, and Linear Displays.
- Video Filter 10 kHz, 100 Hz, and 10 Hz Positions.
- Calibrated Logarithmic and Linear Display Sensitivity Controls.
- Base Line Clipper for Better Viewing of Display.
- Price: $2,950.



8552A—Economy

- 25:1 IF Filter Factor.
- 50 Hz Minimum Bandwidth.
- Log and Linear Displays (Log is 10 dB/Div).
- Video Filter 10 kHz and 100 Hz Positions.
- Calibrated Logarithmic and Linear Display Sensitivity Controls.
- Base Line Clipper for Better Viewing of Display.
- Price: $2,275.



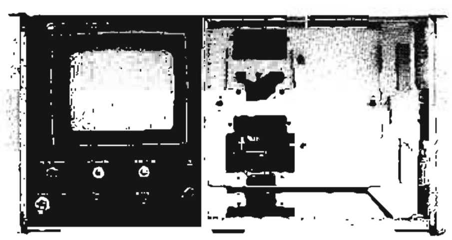
The Display Sections

141T—Variable Persistence

- Variable Persistence for Those High Resolution Slow Scans.
- Storage for Signal Comparison and Study.
- Conventional Standard Persistence Operation Available.
- Internal Graticule to Eliminate Parallax Reading Errors.
- Accepts Time Domain Oscilloscope Plug-ins as Well as Any Spectrum Analyzer Frequency Domain Tuning or IF Section.
- 8-Division Linear Display and 70 dB Logarithmic Display.
- Price: $1,800.

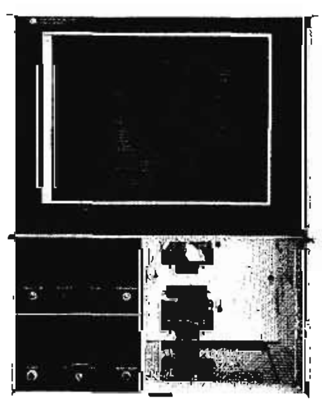
140T—Standard Persistence

- Standard Persistence P-7 Phosphor.
- Internal Graticule to Eliminate Parallax Reading Errors.
- Accepts Time Domain Oscilloscope Plug-ins as Well as Any Spectrum Analyzer Frequency Domain Tuning or IF Section.
- 8-Division Linear Display and 70 dB Logarithmic Display.
- Price: $950.



143S—Large Screen

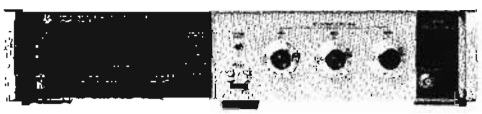
- Large Screen Viewing for Demonstration, Lectures, Etc.
- Internal Graticule to Eliminate Parallax Reading Errors.
- Accepts Time Domain Oscilloscope Plug-ins as Well as Any Spectrum Analyzer Frequency Domain Tuning or IF Section.
- 8-Division Linear Display and 70 dB Logarithmic Display.
- Price: $1,700.



COMPANION INSTRUMENTS
Expand analyzer performance
100 kHz to 18 GHz

Tracking Generators

100 kHz-110 MHz



8443A Price: $3,600

8443B Price: $2,075

500 kHz-1300 MHz

8444A Price: $2,950

With the 8443, the 8553B system becomes a:

- SWEPT FREQUENCY RESPONSE MEASUREMENT SYSTEM
  - Frequency Resolution <10 Hz
  - Amplitude Resolution 0.1 dB
  - Dynamic Range >120 dB
- SWEEP GENERATOR
  - Residual FM <1 Hz peak-to-peak
  - Calibrated Output −120 dBm to +10 dBm
  - Output Flatness ±0.5 dB (8443A only)
  - Frequency Accuracy 10 Hz
- SELECTIVE FREQUENCY COUNTER (8443A ONLY)
  - Sensitivity 25 nV (−140 dBm)
  - Selectivity 10 Hz
  - Resolution 10 Hz

With the 8444A (use with 8554L or 8555A), the spectrum analyzer system becomes a:

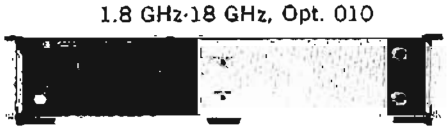
- SWEPT FREQUENCY RESPONSE MEASUREMENT SYSTEM
  - Frequency Resolution 1 kHz
  - Amplitude Resolution 0.1 dB
  - Dynamic Range >90 dB
- SWEEP GENERATOR
  - Residual FM 400 Hz peak-to-peak (8554L); 200 Hz (8555A)
  - Calibrated output 0 dBm to −10 dBm
  - Flatness ±.75 dB

Perform precision frequency measurements:

- EXTERNAL COUNTER OUTPUT
  - Unknown signals ±10 kHz accuracy
  - Frequency response ±400 Hz

Automatic Preselectors

8445A
10 MHz-18 GHz, Standard
1.8 GHz-18 GHz, Opt. 010



Price: Standard, $2,000; Opt. 010, $1,400

8445A
10 MHz-18 GHz, Opt. 020
1.8 GHz-18 GHz, Opt. 030

Price: Opt. 020, $2,200; Opt. 030, $1,600

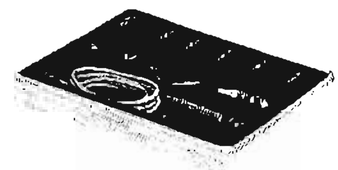
With the 8555A tuning section, the 8445A preselector:

- ELIMINATES ALL UNWANTED RESPONSES.
- IMPROVES DYNAMIC RANGE by Eliminating Harmonic Distortion Products.
- IMPROVES ANALYZER INTERMODULATION DISTORTION Characteristics for Signals Spaced Down to 50 MHz.
- Prevents Analyzer LO Power from Interfering with Sensitive Circuitry.
- Allows Use of 2, 4, 6, AND 8 GHZ SCANS for Signal Measurement Not Just Observation.
- Completely AUTOMATIC OPERATION Leaves User Free to Concentrate on Measurement Itself.
- DISCONNECTS FROM ANALYZER for Critical Measurements So That Maximum Analyzer Sensitivity and Best Frequency Response Are Available.

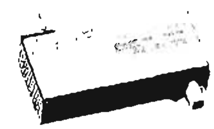
1121A

High Impedance Probes

For making signal measurements without disturbing circuitry. (See Pages 419 and 173.)



10020A



8430 Series

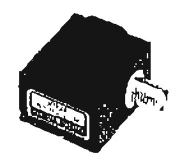
Passive Filters

To improve the performance of the analyzer by eliminating unwanted responses. (See Page 394.)

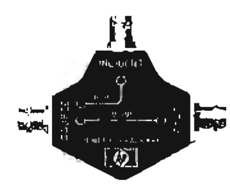
External Mixer

To extend the frequency range of the analyzer to 40 GHz. Taper sections for 12.4-18 GHz (11518A), 18-26.5 GHz (11519A) or 26.5-40 GHz (11520A) bands are required.

Price: $200 (Mixer only).
$125 (Taper sections each).



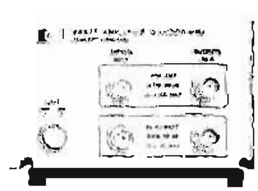
11517A



8721A

Directional Bridge

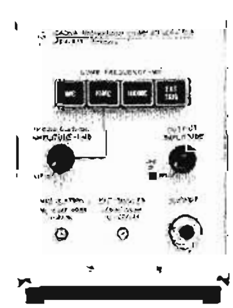
For making return loss measurements from 100 kHz to 110 MHz. (See Page 420.)



8447 Series

Preamplifiers

Improve noise figures of 8553B, 8554L and 8555A by 16 dB and more. (See Page 34.)



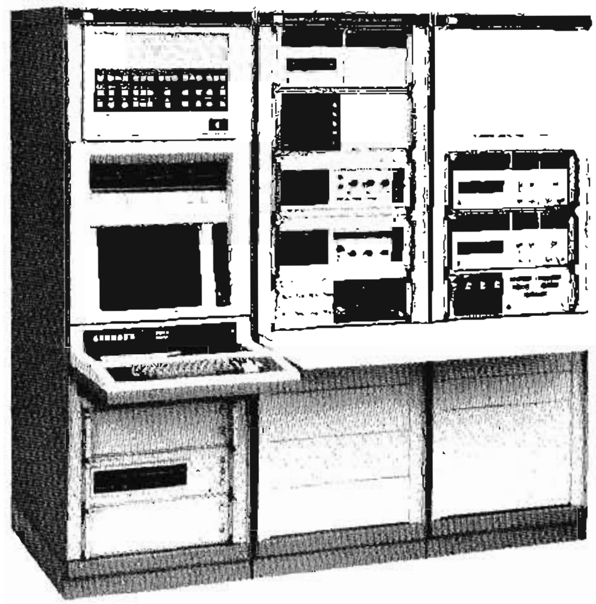
8406A

Comb Generator

For precision frequency measurements to .01% accuracy. Usable up to 5 GHz.

Price: $675.

AUTOMATIC SPECTRUM ANALYZERS
Spectrum monitoring, component testing
Model 8580B



Typical 8580B System
10 kHz-18 GHz

- The workable answer for spectrum monitoring and management
- The economical solution for testing RF/microwave components and subsystems.
- The new approach to a broad range of signal analysis needs

Description

The 8580B Automatic Spectrum Analyzer is a flexible measurement system for applications in spectrum monitoring and network characterization from 10 kHz to 18 GHz. This system consists of a variety of programmable instruments that are controlled from a small instrumentation computer. The measurement heart is a calibrated receiver with programmable tuning and bandwidth. This receiver can be tuned from 10 kHz to 18 GHz by simple one line statements in BASIC measurement programs. Receiver bandwidth is selectable from 10 Hz to 300 kHz. Other programmable system functions include input selection (up to 8 ports) and sensitivity (down to −130 dBm).

Optional signal sources expand the capability of the 8580 systems. Precision RF sources, with programmable level and frequency, supply signals required to excite test devices for network analysis measurements.

Applications

The 8580B Automatic Spectrum Analyzer is a valuable tool for gathering spectral density data on signals present in complex electronic equipment or in a geographic region. RFI testing, for example, is enhanced by the automatic system's ability to correct for sensor transfer functions and compare measured data against specification limits. Performance of a complex communication network can be continually monitored to report network performance on a regular basis. Similarly, radiation in a particular locale can be surveyed to gather statistics on available spectrum or unauthorized transmissions. These applications emphasize an important feature of the Automatic Spectrum Analyzer; totally unattended operation. The 8580 may be programmed to measure, analyze, and record results, and hence run without human intervention, for long periods. This makes comprehensive monitoring a practical tool for spectrum management.

Network characterization is also greatly advanced through use of an Automatic Spectrum Analyzer. An 8580 can measure the magnitude of reflection and transmission coefficients of linear networks, as well as the distortion parameters (harmonic, intermodulation, cross-modulation) of non-linear devices such as amplifiers. Frequency translators such as mixers, modulators, and frequency multipliers are also readily characterized. Additionally, oscillators can be evaluated for output level, distortion, and spurious output signals.

For both surveillance and network characterization applications, the 8580's absolute calibration (frequency and power), broad frequency coverage, high frequency accuracy, wide measurement range, speed, and ease of programming, combined with the flexible hardware option list, offer a measurement system that can be tailored to your application. Contact your local Hewlett-Packard office for complete technical information.

POWERFUL TECHNIQUES FOR LOW FREQUENCY ANALYSIS

- Analyze frequencies down to dc.
- Completely characterize random signals.
- Peform statistical analysis on-line.
- Get accurate results, using digital techniques.

These are some of the unique characteristics of the Hewlett-Packard line of Digital Signal Analyzers. These instruments are finding extensive use in situations where low frequency signals (below about 250 kHz) need to be analyzed in detail, on line, at a reasonable cost. The Digital Signal Analyzers are described on the following pages, 460-467.

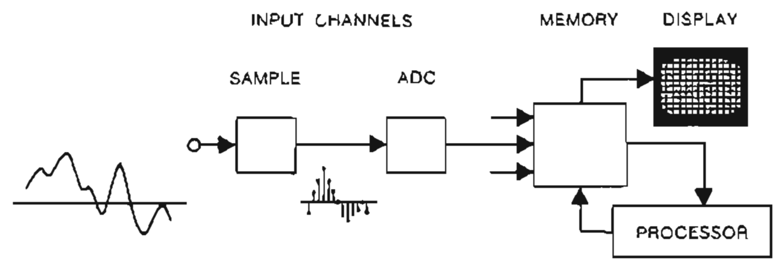


Figure 1. Simplified Block Diagram.

What is DSA?

The signal analyzers described on the preceeding pages are ideally suited to characterizing coherent or relatively noise-free signals. There are certain measurement problems, however, which they cannot solve. "Traditional" instrumentation typically is incapable of:

Analyzing random signals or signals obscured by noise.

Measuring the joint properties of two or more signals.

Computing complex statistical functions of a signal.

Analyzing very low frequency signals (below about 20 Hz).

In the past, these problems could be tackled only by a general purpose digital computer which was usually off-line and expensive, and required special training to operate. The DSA line offers the advantages of digital computation without these drawbacks, at considerably less cost than custom-built systems.

Figure 1 shows the basic functional components of a Digital Signal Analyzer. One or more inputs are sampled at regular intervals, Δt. A number of sampled amplitude values are converted to digital form and fed to the memory. The desired function is computed in the arithmetic unit using a series of input samples, and the result is again stored in memory. The content's of the memory can be read out to a display, allowing observation of the results during analysis. The whole operation is overseen by a controller.

Advantages

The use of digital techniques gives these analyzers several advantages over analog instruments. They are able to analyze very low frequency signals, down to dc, with high accuracy and stability. They are also flexible, being able to compute many different statistical functions with a wide variety of averaging times.

Equally important, digital signal analyzers are easy to use. They can be operated without special programming, and they have built-in, calibrated CRT displays for easy interpretation of results. Outputs to X-Y recorders for hard copy are standard, and each analyzer can be easily interfaced to a computer for further analysis of data.

These advantages have opened up several new applications for signal analysis, many of them in fields which are not traditional users of electronic instrumentation.

Applications

Here are just a few applications in which the benefits of digital signal analysis are particularly significant.

Bearing fault detection: Local vibrations of a bearing are detected using an accelerometer mounted on the bearing housing. The output of the accelerometer is fed to a Fourier Analyzer which can identify spectral "signatures" of the vibration signal. Such quantities as roughness, out of round, or lack of centering can modify the signature of a good bearing. Interpreting these signatures may require complex manipulation of the spectra; this is greatly simplified by use of the Fourier Analyzer's computer.

Certain localized faults, such as cracks or pits in the bearing surface, emit "clicks" each time they pass the point of contact. These are best detected by time averaging, which separates vibrations which are synchronous with shaft rotation from those which are not. This averaging can be performed best by the 5480S Signal Analyzer which is a special purpose signal averager. The user therefore has a choice between the low cost unit for this specific operation, or the general purpose Fourier Analyzer, which can perform more complex analysis in addition to signal averaging.

Study of aerodynamic turbulence: Researchers in this area are very familiar with the advantages of statistical analysis for extracting information from low frequency random signals. In particular, the cross-correlation function between the outputs of two transducers down stream from a model in a wind tunnel can measure the way in which turbulence decays as it progresses down the stream. Model 3721A Correlator can measure this correlation function much more rapidly and conveniently than an off-line computer.

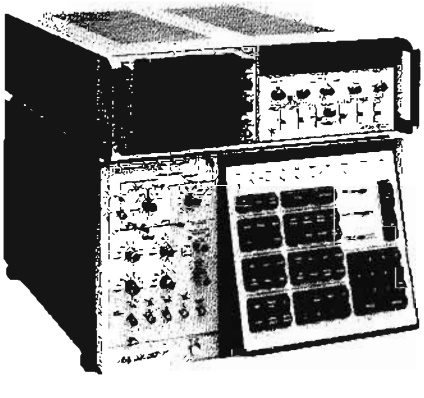
Measurement of dynamic system response: New techniques of testing such systems as aircraft servos, process control systems, and voice communication channels involve the use of noise as a test signal. The advantages of noise are that it contains all frequencies in the band of interest, and it simulates the kind of signals which perturb these systems during normal operation. Measurement of the cross-correlation, transfer, and coherence functions between the noise input and the output of these systems can characterize them very rapidly even during normal operation, in the presence of other signals.

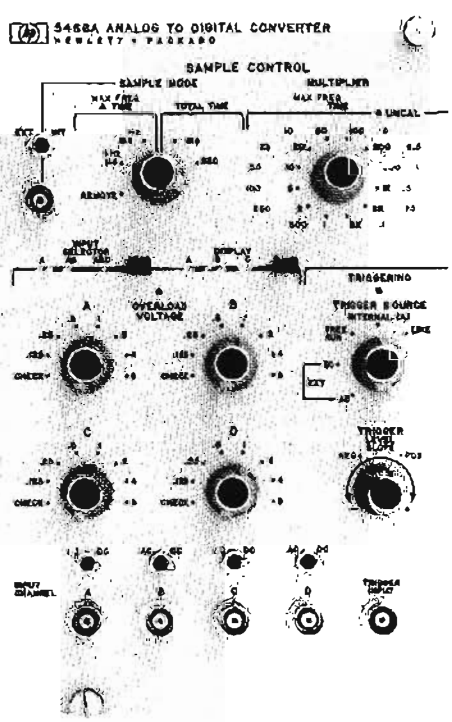
There are many other areas in which DSA is proving a useful measurement tool. Further information is available in the form of application notes for each instrument in the line.

FOURIER ANALYZER
4 Input Channels, DC to 100 kHz
Model 5451A

Features

- Increased Frequency Range, DC to 100 kHz
- Expandable ADC to 4 Channels, 12 Bits
- Relocatable Software
- 80 dB Dynamic Range
- Keyboard Control—no software knowledge needed
- Real Time Analysis—three speeds to choose from





5466A (4 channel option)

Description

The 5451A is an integrated system which includes an analog-to-digital converter (ADC), display unit, digital processor, complete software package, and a user-oriented keyboard, and can provide the complete answer to low frequency signal analysis problems. The system employs powerful mathematical techniques such as the Fourier Transform and statistical averaging to calculate: transfer function, coherence function, auto power spectrum (with double precision preserving wide dynamic range), cross power spectrum, auto and cross correlation, to name a few. Complete digital operation assures maximum accuracy with system flexibility, yet no computer programming knowledge is required to operate the system. The user simply presses keys on the keyboard to perform the measurement desired.

The Relocatable Software and a "User Program Key" allows user written programs in Fortran or Assembly language to be easily integrated into the system, providing almost unlimited flexibility and measurement power.

Three speeds of Real-Time Analysis are offered with the 5451A. Optional 5470A Fast Fourier Processor and 5471A FFT Arithmetic Unit offer real-time power spectrum calculations to 18 kHz and 2.0 kHz respectively, with the standard 5451A providing this calculation real-time to 375 Hz. These increased performance options may be added at any time without affecting the keyboard operation of the system. Since the digital processor is an HP 2100A computer, the 5451A can optionally include peripherals such as digital magnetic tapes, discs, etc. for expanded system performance.

The new 5466A ADC provides the capability for 4 channel simultaneous measurement to 100 kHz, 10 or 12 bit resolution and remote programmability.

Measurement application areas

- Mechanical Impedance
- Vibration Modal Analysis
- Transfer Functions
- Signature Analysis
- Acoustics
- Communications
- Biomedicine

Major specifications

Amplitude Range: .125 to 8 V peak in steps of 2.
Input Impedance: 1 MΩ shunted by 75 pF max.
Conversion Gain (per channel)
Accuracy: $\pm .1\% \pm .16 \times 10^{-5}\%$/Hz of full scale.
Number of Channels: 2, optionally 4.
Resolution: 10 bits, optionally 12 bits.
Input Frequency Response:
Small signal, >1 MHz - 3 dB.
Large signal, 500 kHz.
Sample Rate Control:
Max. frequency mode: 0.1 Hz to 100 kHz in steps of 1, 2, 5.
ΔF mode: 0.002 Hz to 1000 Hz in steps of 1, 2, 5.
Data Word Size: 16 bit real and 16 bit imaginary, 32 bits preserved for double precision functions.
Dynamic Range: 80 dB (72 dB with 5470A or 5471A).
Computational Speed (with HP 2100A Computer):

Configuration	Fourier Transform		Power Spectrum Average	
	128 pts.	1024 pts.	128 pts.	1024 pts.
5451A	75.0 ms	980.0 ms	133.0 ms	1360.0 ms
5451A/5471A	15.4 ms	160.0 ms	33.5 ms	250.0 ms
5451A/5470A	3.3 ms	15.2 ms	11.5 ms	28.9 ms

FOURIER PROCESSORS
Stand alone system modules
Model 5470A, 5471A

5471A Arithmetic Unit
Low cost, hardwired fourier transform arithmetic unit

Features:

- Fourier Transform (1024 point) in 160 ms*
- Plug-in for all HP 2100 series computers
- Low Cost
- 4 to 2048 point transform (8192 optional)
- Extend HP Fourier Analyzer capability

Description:

The 5471A Fast Fourier Transform Arithmetic Unit is a special-purpose, high-speed arithmetic unit designed to perform the necessary array manipulations for signal analysis based on the Fast Fourier Transform. It operates on blocks of 16-bit data words representing either time or frequency domain data. The 5471A performs the following array manipulations: forward and inverse Fourier transform, Hanning, real, complex and complex conjugate block multiplication, scaling and block addition. Block scaling, block addition and self complex conjugate block multiplication can be single or double precision, yielding up to 72 dB dynamic range for auto power spectrum averaging.

For stand-alone use, the 5471A is supplied with a driver callable from HP Assembly language or from HP Fortran.

When the 5471A FFTAU is incorporated in the HP 5451A Fourier Analyzer, the processing speed can be increased a factor of six without affecting the standard keyboard operation of the system.

5471A

Specifications

Operation times with 2100A computer (1024 word block size)*

Fourier Transform	161 ms
Hanning	19 ms
Block Multiply	29 ms
Addition	31 ms
Self Complex Conjugate Block Multiply	21 ms

Memory requirements: driver: 1536 words; data: 4 to 2048 words.

Power requirements: +4.85 volts = 8 amps, −2 volts = .25 amps.

Price: $4500.

*With 2100A.

5470A Fast Fourier Processor
High speed signal analysis at an attractive cost

Features:

- Fourier Transform (1024 point) in 15.2 ms
- Internal 4K Memory, 8K optional
- Parallel Processing with host computer

Descriptions:

The 5470A Fast Fourier Processor is a special-purpose, stand-alone digital processor designed to perform routines for FFT signal analysis. The fast processor operates under the functional control of any 2100 series Hewlett-Packard computer and is especially designed to be compatible with the HP 5451A Fourier Analyzer System.

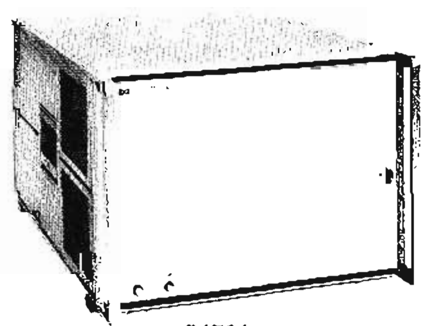
The 5470A accepts either time or frequency domain data in single or dual channel form into a 4096- or 8192-word memory and performs these array manipulations:

Forward and Inverse Fourier Transform,
Time Domain Weighting by Hanning,
Real and Complex Block Multiplication,
Complex Conjugate Block Multiplication,
Block Addition, and
Block Scaling.

The 5470A also performs complete spectrum analysis functions of:

Power and Cross Power Spectrum, and
Auto and Cross Correlation.

By doing division routines in the host computer, the system can use the fast processor options to accomplish coherence function and transfer function operations at extremely high speeds.



5470A

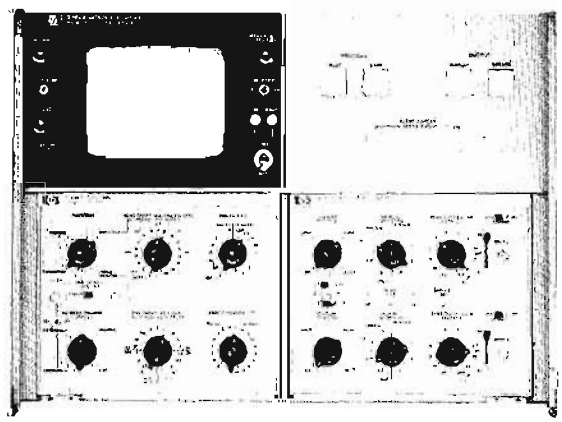
The 5470A operates through two I/O channels, and with the general purpose driver callable in Fortran or Assembly language, the full power of the 5470A becomes available through user written routines.

When the 5470A is installed in an HP 5415A Fourier Analyzer system, the system software is configured to include the 5470A driver, allowing keyboard control of the 5470A. Processing speeds can be increased up to 100 times with no change in user operations.

Options are available for additional 4K memory, and for 4096 point block size.

Prices start at $25,000.

SIGNAL ANALYZER
Signal averaging and statistical analysis
Models 5480S, 5481A, 5494A



5480B

5480S Signal Analyzer

Signal averaging provides an unparalleled method of recovering a signal buried in background noise. Featuring true and weighted averaging, real time variance, and the ability to measure correlation functions and histograms, the 5480S brings a new dimension to the analysis of noisy signals.

True Averaging: Display always represents true average calibrated in volts per centimeter; the display does not "grow" as in conventional summation but remains stable as the noise disappears.

Weighted Averaging: A time varying signal may be observed in this mode which exponentially de-emphasizes old information in favor of new.

Summation Averaging: Algebraic summation process. Signal will grow from stable base line. If placed in AUTO mode, display will be automatically calibrated at the end of the preset number of sweeps.

Flicker Free: Continuous display for all sweep speeds allows viewing the accumulated data while acquisition takes place.

Variance: The statistical variance is a measure of the deviation of a signal about its mean. The 5480S gives you, point by point, the real time variance of Channel A by averaging the square of the noise present in the signal. This allows you to spot variations in your signal or tells you exactly when the display represents the true average.

Multiple Inputs: The 5485A Two Channel Input and the 5487A Four Channel Input plug-ins offer multiple channel capability.

Histograms: The 5480S provides frequency and time interval histograms, and multi-channel scaling.

Time Interval: Time between synchronization pulses. Horizontal calibration by time base.

Frequency: Start and stop determined by time base. Horizontal calibration by time base. This capability can be extended with the H15-5326B, to include trend analysis, such as post stimulus histograms, and dwell and latency histograms.

H15-5326B Counter: A modified 5326B (catalog page 264), this unit can set precise threshold levels for dwell and latency histograms, and provides a gated output for time interval trend analysis.

Multi-Channel Scaling: The analyzer sweeps through memory remaining at each channel for a preset time. A plot of the number of input pulses versus time is displayed.

Correlation: With the 5488A plug-in, the frequency of a noisy signal can be obtained by auto-correlation, while the common frequency and relative phase difference of two noise signals can be obtained by cross-correlation.

Input Filtering: Each 5480S System includes the 5489A Two Channel Input Filter; in addition to removing high frequency noise to reduce averaging time, the X10 gain provided by the 5489A increases resolution (page 465).

5481A Signal Analyzer System

Combining the 5480S with the HP 2100A Digital Computer, the 5481A Signal Analyzer System permits extensive on-line analysis of gathered data. Fourier transforms, power spectra, curve integration, smoothing, and differentiation, and many other data manipulating functions are possible. Or the 5481A System may be used for automating your other instrumentation providing you with multiplexed analog to digital conversion, display output on built-in 5480 Oscilloscope, a 1000 word buffer memory, and controlling software.

Prices

All 5480S Signal Analyzer Systems include the 1042 word, 24 bit Memory/Display mainframe, the 5486B Control Plug-in, and the 5489A Two Channel Low-Pass Filter/Amplifier; the digitizing plug-in is chosen by option.

5480S Signal Analyzer	$ 9950
Opt 001 5485A Two Channel Input	N.C.
Opt 002 5487A Four Channel Input	+$ 375
Opt 003 5488A Correlation/Average Input	$ 475
5489A Low-Pass Filter	$ 425

The basic 5481A Signal Analyzer System includes the 5480S, the 2100A Digital Computer, the 2752A Teleprinter, and the 10625A Interface with complete software.

5481A Signal Analyzer System	$26,200

Complete specifications available on the 5480B Technical Data Sheet. Consult Ordering Information Guide for pricing details.

CORRELATOR, SPECTRUM DISPLAY

Real-time statistical signal analysis system

Models 3721A, 3720A

3721A Correlator

The Model 3721A Correlator is a digital statistical signal analyzer covering the range dc to 250 kHz. It computes autocorrelation, crosscorrelation, and amplitude probability functions. In addition, a signal recovery facility uses signal averaging to improve the signal-to-noise ratio of a repetitive signal buried in noise. The resultant functions are displayed on a built-in CRT.

The versatile analysis and averaging capabilities combined with portability, automatic calibration, built-in CRT and real-time operation make the 3721A an ideal analyzer for both laboratory and field use.

Major Specifications

Input signal bandwidth: dc to 250 kHz.
Input range: 40 mV rms to 4 V rms.
Functions: Autocorrelation, Crosscorrelation, Probability (Density and Integral), Signal Recovery.
Number of points: 100 points computed and displayed for each function.
Sampling interval: 1 s to 1 μs (1 Hz to 1 MHz sampling rates). External clock facility allows any interval ≥1 μs to be selected. In Correlation and Signal Recovery the time between displayed points is equal to the sampling interval.
Averaging: two modes are provided:
- **Summation:** computation automatically stopped after a fixed number of samples has been taken. Number of samples selectable from 128 to 128 x 1024.
- **Exponential:** continuous averaging with time constant selectable from 36 ms to over 10^7 seconds.

Calibration: vertical calibration is automatically displayed on an illuminated panel (except Probability).
Outputs:
- All computed functions are displayed on the built-in CRT.
- Analog outputs are provided for use with an X-Y recorder and external oscilloscope.
- Digital outputs allow the transfer of computed data to any hp digital computer or hp paper tape punch (2753A, 2895A or 8100A). Extra plug-in assemblies are required, type depending on the peripheral used.

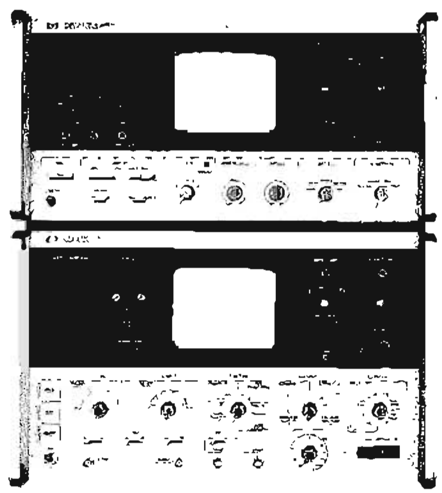
Price: Model 3712A, $8500.

3720A Spectrum Display

The 3720A Spectrum Display is an unique add-on unit for the Correlator, to complement and extend its capability by Fourier transforming any time display on the 3721A and presenting its equivalent frequency function on a built-in display.

The 3720A performs the Real and/or Complex transformation of autocorrelation and crosscorrelation functions to produce the Power and Cross Spectral Density functions respectively, and converts signal recovered data into frequency information.

Together the 3721A Correlator and 3720A Spectrum Display, each with its own CRT display, form an analysis system giving both time and frequency information simultaneously.



3720A

3721A

Major Specifications

Input data: digital data is transferred from the Correlator and held in either of two stores, labelled 1 and 2.
Computed transforms: either the Real or Complex transform can be computed of the contents of the store 1, the contents of store 2, or the contents of stores 1 and 2 together.
Frequency range: 0.005 Hz to 250 kHz using internal 3721A clock. Extendable down to dc with external clock.
Displayed frequency range: two decades of frequency are displayed, the highest frequency being $1/2\Delta t$ Hz (Δt is the 3721A Timescale setting).
Dynamic range: ratio of full scale signal to noise level, for fixed integrator gain, is better than 50 dB.
Gain: continuously variable over a 2 decade, 40 dB, range in seven discrete steps, with intermediate vernier.
Window: two choices are available:
- OFF—natural window, nominal bandwidth $1/200\ \Delta t$.
- ON—triangular window, nominal bandwidth $1/100\Delta t$.

Interpolation: two modes available:
- MANUAL—computes and displays 100 frequency points. Frequencies of all 100 points can be simultaneously and equally varied over a frequency interval, $1/200\ \Delta t$.
- AUTO—automates the manual interpolation, calculating 10 equispaced points across each frequency interval.

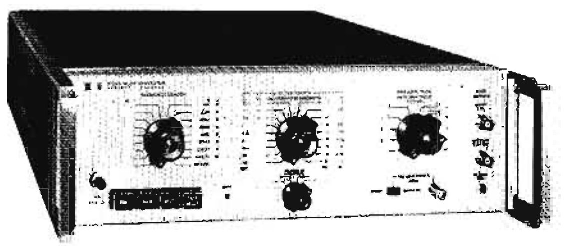
Transform presentation: all combinations of the following axes are available for display.
- Vertical axis—Phase, Log Mod, Modulus, Imaginary, Real.
- Horizontal axis—Frequency, Log Freq, Real, Phase.

CRT display: built-in variable persistence CRT with storage facility.
X-Y recorder: separate horizontal and vertical analog outputs corresponding to the CRT display.
Price: $5995.

NOISE GENERATOR; FILTER

Calibrated noise; low pass filter/amplifier

Models 3722A; 5489A



3722A

The Model 3722A Noise Generator uses digital techniques to synthesize binary and Gaussian noise patterns. These 'pseudo-random' patterns, which are of known content and duration, are repeated over and over without interruption. Since one pattern is identical with the next, each pattern has the same effect on the system under test: for this reason, pseudo-random noise signals cause no statistical variance in test results. The Model 3722A also generates truly random binary and Gaussian noise.

The basis of the Model 3722A is a binary waveform generator—a shift register which operates under the control of either a feedback mechanism (pseudo-random mode) or a random noise source (random mode). The shift register is clock triggered, with the result that transitions between output levels of the binary waveform can occur only in time with beats of the clock—although whether or not a transition occurs on a given beat is determined by the feedback mechanism or random noise source. The binary output has a $(\sin x/x)^2$ shaped spectrum and the Gaussian output, which is derived from the binary signal by precision low-pass filtering, has an almost rectangular spectrum. Both binary and Gaussian outputs are controllable in bandwidth, but the output power remains constant regardless of selected bandwidth—a particularly useful feature, of importance in applications where usable noise power must be made available in a very restricted frequency band. The frequency of the first null in the binary spectrum is selectable from 0.003 Hz to 1 MHz, and the bandwidth (at −3 dB point) of the Gaussian noise is selectable from 0.00015 Hz to 50 kHz.

Outputs from the Model 3722A are available at fixed amplitudes of ±10 V (binary) and 3.16 V rms (Gaussian), and a precision amplitude control provides a variable output of either signal ranging from 0.1 V rms up to the level of the fixed outputs.

Specifications

Binary output (fixed amplitude)

Amplitude: ±10 V.
Output impedance: <10Ω.
Load impedance: 1 kΩ minimum.
Rise time: <100 ns.
Power density: approximately equal to (clock period x 200) V^2/Hz at low frequency end of spectrum.
Power spectrum: $(\sin x/x)^2$ form: first null occurs at clock frequency, and −3 dB point occurs at 0.45 x clock frequency.

Gaussian output (fixed amplitude)

Amplitude: 3.16 V rms.
Output impedance: <1Ω.
Load impedance: 600Ω minimum.
Zero drift: <5 mV change in zero level in any 10°C range from 0° to +55°C.
Power density: approximately equal to (clock period x 200) V^2/Hz at low frequency end of spectrum.
Power spectrum: rectangular, low-pass: nominal upper frequency f_0 (−3 dB point) equal to 1/20th of clock frequency. Spectrum is flat within ±0.3 dB up to ½ f_0, and more than 25 dB down at 2 f_0.
Crest factor: up to 3.75, dependent on sequence length.

Variable output (Binary or Gaussian)

Amplitude (open circuit)
Binary: 4 ranges: ±1V, ±3 V, ±3.16 V and ±10 V, with ten steps in each range, from x 0.1 to x 1.0.
Gaussian: 3 ranges: 1 V rms, 3 V rms and 3.16 V rms, with ten steps in each range, from x 0.1 to x 1.0.
Output impedance: 600Ω ±1%.

Main controls

Sequence length switch: first 17 positions select different pseudo-random sequence lengths: final position selects random mode of operation (INFINITE sequence length). Sequence length (N) is number of clock periods in sequence: possible values of N are 15, 31, 63, 127, 255, 511, 1023, 2047, 4095, 8191, 16383, 32767, 65535, 131071, 262143, 524287, 1048575.
$N = 2^n - 1$, where n is the range 4 through 20.
Clock period switch: selects 18 frequencies from internal clock:

Clock period	Clock frequency	Gaussian noise bandwidth
333 s	0.003 Hz	0.00015 Hz
100 s	0.01 Hz	0.0005 Hz
33.3 s	0.03 Hz	0.0015 Hz
10 s ↓ 3.33 µs	0.1 Hz ↓ 300 kHz	0.005 Hz ↓ 15 kHz
1 µs	1 MHz	50 kHz

Internal clock

Crystal frequency: 3 MHz nominal.
Frequency stability: <±25 ppm over ambient temperature range 0° to +55°C.
Output: +12.5 V rectangular wave, period as selected by CLOCK PERIOD switch.

External clock

Input frequency: usable BINARY output (pseudo-random only) with external clock frequencies up to 1 MHz.
Input level: negative-going signal from +5 V to +3 V initiates clock pulse.
Maximum input: ±20 V.

Secondary outputs

Sync: negative-going pulse (+12 V to +1.5 V) occurring once per pseudo-random sequence; duration of pulse equal to selected clock period.
Gate: gate signal indicates start and completion of selected number of pseudo-random sequences (1, 2, 4 or 8, selected by front panel control). Two outputs are provided:
1. Logic signal: output normally +12.5 V, falls to +1 V at start of gate interval and returns to +12.5 V at end of interval.
2. Relay changeover contacts: gate relay switching is synchronous with logic signal.

Binary relay: relay changeover contacts operate in sync with binary output signal.

Remote control

Control inputs: remote control inputs for RUN, HOLD, RESET and GATE RESET functions are connected to 36-way receptacle on rear panel.
Sequence length indication: 18 pins plus one common pin on the 36-way receptacle are used for remote signalling of selected sequence length (contact closure between common pin and any one of the 18 pins).

General

Dimensions: 16 3/4 in. wide, 5 7/32 in. high, 16 3/8 in. deep (425 x 132.6 x 416 mm).
Weight: net 23 lbs (10,5 kg); shipping, 30 lbs (13,5 kg).
Price: Model 3722A, noise generator, $2975.

Option 001
Zero moment option: shifts relative position of sync pulse and pseudo-random binary sequence such that first time moment of sequence, taken with respect to sync pulse, is zero (sequence shift mechanism is operative only when selected sequence length is ≤1023): option 001 also provides facility for inverting binary output signal. $58

Model 3722A Option H01

Model 3722A Option H01 is a standard Model 3722A Noise Generator modified to provide a second binary output which can be delayed by a selectable number of clock periods with respect to the main binary output. The delayed binary output is available only when the instrument is in the pseudo-random mode, that is, generating repeated noise patterns.

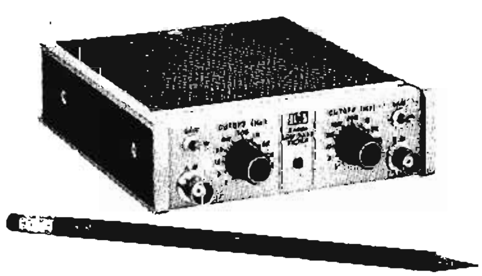
The delay introduced between the two binary outputs is selected by three decade switches on the front panel. These switches, which are set according to a conversion table supplied with the instrument, provide almost all possible delays ranging from zero to the number of bits (N) in the sequence in use.

Specifications

Delayed binary output
Typical performance figures for the delayed output are:
Amplitude: switches between +1.5 V and +12 V.
Maximum sink current at 1.5 V level: 10 mA.
Impedance: 50Ω (+1.5 V) and 600Ω (+12 V).
Rise time: <50 ns.*
Fall time: <20 ns.*
Price: Model 3722A Option H01, $3255.

*Measured with ÷10 probe shunted by 10pF.

5489A Low Pass Filter/Amplifier



5489A

The model 5489A is a high quality two channel filter of remarkably small size and low cost. It is intended for general purpose use, and is recommended for use with all the analyzers described in this section of the catalog.

Variable bandwidth and gain

The 5489A has a low pass Butterworth response, having an attenuation slope of 12 dB/octave above the cut-off frequency. The bandwidth of each channel is selectable from DC-1 Hz to DC-30 KHz in 10 steps. In addition, the gain of each channel may be set to either X1 or X10, allowing simultaneous amplification and filtering. Both channels may be cascaded to increase the gain to X100 and steepen the attenuation slope to 24 dB/octave.

Specifications

General:

Cutoff Frequency (3 dB attenuation): 1 Hz to 30,000 Hz. Selectable in 1, 3, 10 steps and OUT (by-pass). Frequency accuracy ±10% except 30,000 Hz setting.
Maximum Attenuation: 80 dB.
Passband Gain: X1 (0 dB) ±1% or X10 (20 dB) ±3%.
Noise and Hum (Referred to input, with 1 KΩ source impedance): 100 μV rms in 50 kHz band. 250 μV rms in 500 kHz band.
DC Offset Drift (Referred to input with 1 KΩ source impedance): 100 μV/°C.

Input:

Range: ±10 Volt P-P on X1 gain, ±1 Volt P-P on X10 gain.
Protection: Protected to ±30 Volts.
Impedance: 1 megohm shunted by 75 pF, Single-ended.

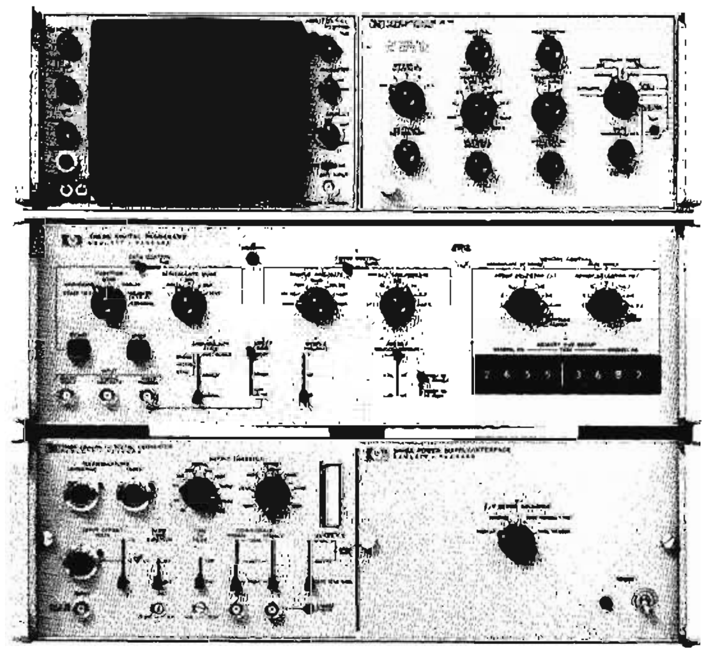
Output:

Level: ±10 Volts, maximum, at ±5 mA, DC through 10 kHz.
Slew Rate: 0.6 V/μs, maximum.
Protection: May be shorted to ground indefinitely.
Overload Recovery: 50 μs for 100% overload.
Output Impedance: 50 ohms, nominal, single-ended.

Physical:

Environmental: Operating Range, 0 to 55°C.
Power: 115/230 V ac, 50-400 Hz, 10 Watts.
Weight: Net 2 lbs, 4 oz. (1,1 kg).
Size: 1½" high x 5⅛" wide x 6" long (3.8 x 1.3 x 15.2 cm).
Price: 5489A Low Pass Filter/Amplifier $425

MULTICHANNEL ANALYZER
8192 channel, 200 MHz clock rate ADC
Model 5401B



H51-180AR Oscilloscope with 5431B Display Plug-In

5422B Digital Processor

5416B Analog-to-Digital Converter in 5410A Power Supply/Interface

5401B Multichannel Analyzer

5401B Multichannel Analyzer

- Performs Pulse Height Analysis, Sampled Voltage Analysis, and Multichannel Scaling
- 8192 Channel Analog-to-Digital Converter, 200 MHz Clock.
- ADC has precision upper and lower discriminators, dc input offset capability, base line monitor, coincidence and anti-coincidence gating, dead time and count rate meter, various output channel and digital offset ranges.
- Standard memory sizes of 1024, 4096, and 8192 channels available.
- 10 MHz Up/Up and Up/Down Multichannel Scaling.
- Interfaces to various peripherals, including Parallel Printer, Teletype, Tape Punch, Tape Reader, Incremental Magnetic Tape, HP 9810A Calculator, HP 2100 Computers.
- 5586A Spectrum Stabilizer available to compensate for gain and baseline drifts.
- Application Note 138 available which describes applications of Multichannel Analyzers.

Other nuclear products

5586A Spectrum Stabilizer: to compensate for gain and base-line drifts of nuclear systems. Application Note 139 describes how the spectrum stabilizer is used. Price: $2400.

5554A Preamplifier: charge-sensitive preamplifier with selectable sensitivity and voltage gain, is combination preamp and amplifier. Price: $360.

5580B NIM Power Supply: provides the output voltages required by the AEC-NBS Standards (TID 20893). Price: $1150.

5582A Linear Amplifier: amplifier with variable pulse shaping capability and suitable for scintillation and gas-flow nuclear detectors, NIM unit. Price: $750.

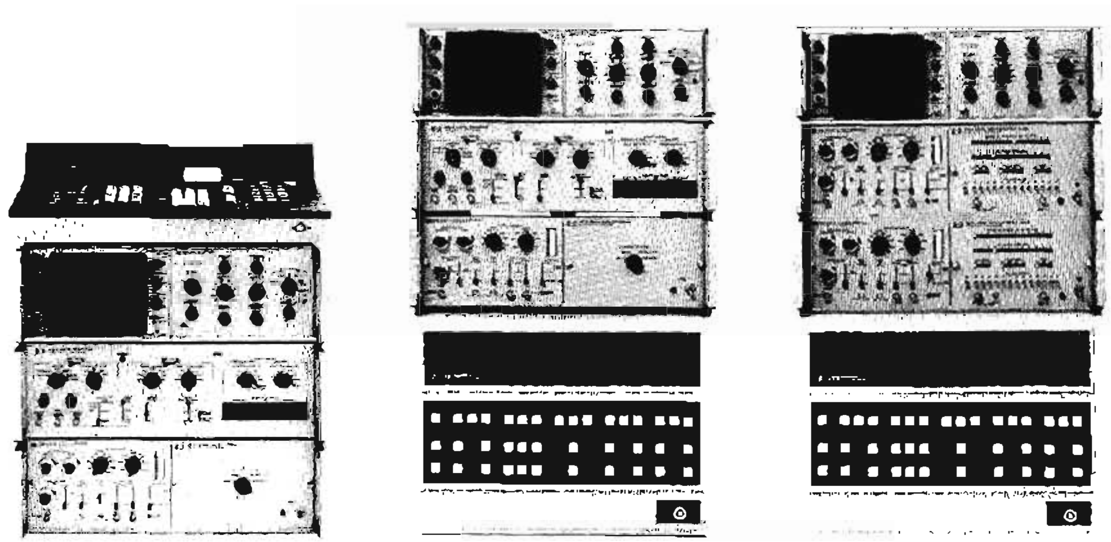
5583A Single Channel Analyzer: operates in Single Channel Analyzer Mode or Dual Integral Mode, NIM unit. Price: $650.

For complete data sheets, prices, application notes, etc., please consult your local Hewlett-Packard office.

NUCLEAR ANALYZER SYSTEM

Calculator & Computer-Controlled

Model 5401B/Option 800, 5402A, 5406B



5401B with Option 800 5402A 5406B

5401B Option 800 MCA/Calculator System

Performs computer-type functions without computer-type costs. Automates data accumulation and reduction with programs you can learn to write in an afternoon (or use ours). The Multichannel Analyzer (MCA) and highly versatile Hewlett-Packard calculator can be used independently. Includes 5401B MCA, 9810A Calculator, 10651A Interface.

5402A MCA/Basic System

A Multichannel Analyzer (MCA) System with control and data reduction by 8K 16-bit HP 2100A Computer. Operates in Hewlett-Packard's BASIC, a computer language that's powerful yet very easy to learn. The versatile general purpose computer can be used alone for other tasks too.

Programmable operations:

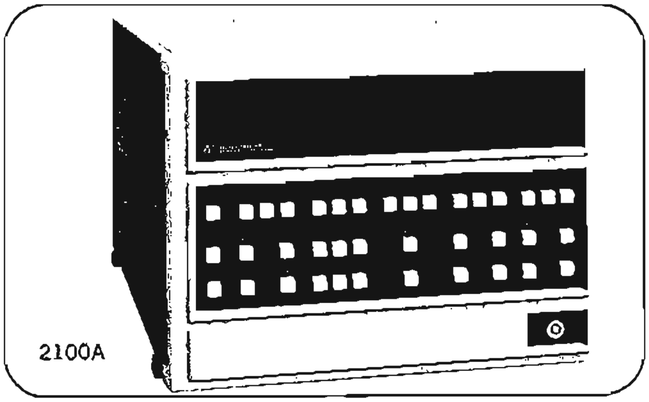
Erase, Accumulate, Display, Parallel Output, Serial output, Serial Input, Transfer (Region A to Region B), Start, Stop MCA/Computer Data Transfer, MCA Status Check, Computer Paper Tape Input/Output, Teleprinter Input/Output.

This system is ideal for the investigator who has a unique data reduction job to do and who wishes to have the computer system output formatted reports, without requiring the services of a professional programmer. Hewlett-Packard provides a starter set of BASIC-language applications programs, including peak analysis, radioassay, spectrum smoothing, peak search, spectrum stripping, log conversion.

5406B Nuclear Analyzer System

- Computer-Based Nuclear System
- Single Parameter, Multiplex Single Parameter, and Multiparameter Analyzer
- Multiparameter Analyzer Operations Include Digital Gating, List (Address) Recording with Magnetic Tape, and Delayed-Time Totalizing
- Analog-to-Digital Converter and Display Subsystem Connect Directly to 2100A Computer
- DMI, DMA, and Program Control ADC-to-Memory Data Transfer Modes
- Up to 32,000 16-Bit Words of Memory Available in 2100A Computer
- Data Channel Size Can Be 16, 20, 24 or 32 Bits
- Wide Range of Peripheral Devices
- Complete Operating System
- Executive Software that Controls:
  - Analyzer Functions
  - Programmed Automatic Operations
  - Foreground, Background, and Interrupt Operations
  - Data Reduction
- Modular Hardware and Software Design
- Data display in slice, isometric, and contour modes
- Single Parameter Peak Analysis, Spectrum Stripping, Background Subtraction, Spectrum Smoothing, and Two Parameter Peak Analysis Subroutines Available with the Standard 5406B System
- Extremely Easy to Incorporate User-Written Subroutines into 5406B

MINICOMPUTER
General-purpose digital computer
Model 2100A



The Thoroughly Modern Mini

The Hewlett-Packard 2100A is a general-purpose digital computer designed for a wide range of small computer applications.

Features built into the 2100A include extended arithmetic instructions, power fail interrupt with automatic restart, memory parity check with interrupt and memory protect. Besides the standard built-in features, dual-channel Direct Memory Access (DMA), Floating Point Hardware and Writeable Control Store (WCS) are also available. Under DMA control, data can be transferred to or from computer memory at rates greater than one million 16-bit words per second. Floating Point Hardware provides a typical ten-fold speed increase for scientific, compute bound algorithms. WCS lets the user add instructions or routines to those of the 2100 microprocessor. Hewlett-Packard provides a microassembler, utilities, I/O routines and drivers that greatly simplify development of microprograms.

A minimum 2100A provides 4096 words of core memory, self-contained power supply and 14 input/output channels.

You can select a wide range of memory sizes up to 32K words, all in mainframe. By including an HP 2155A Extender, you add another 31 input/output channels and power supply.

The 2100A automatically inherits a comprehensive range of proven software packages, including assemblers, compilers, operating systems and subroutines. A complete line of standard computer peripherals and I/O interface kits are also available, permitting complete systems to be tailored around the 2100A. The result is a cost-effective computer that can meet your data processing problems today and continue meeting them as your needs expand.

Memory

Type: folded planar core.
Word size: 16 bit with 17th parity bit.
Page size: 1024 words.
Direct addressing: 2 pages.
Indirect addressing: all pages.
Modular sizes: 4K and 8K word memory modules provide 4, 8, 12, 16, 24 and 32K configurations all in the 2100A mainframe without additional power supply or cabinetry.
Cycle time: 980 nsec.
Loader protection: switch protects last 64 words.

Registers

Accumulators: two (A, B), 16 bits each. Directly addressable.
Memory control: three (T, P, M), 16 bits each.
Supplementary: two (Overflow and Extend), one bit each.
Manual data: one 16-bit switch register.

Floating Point Hardware Execution Times (Optional)

	Minimum	Maximum
Add:	23.5 μsec	59.8 μsec
Subtract:	24.5 μsec	60.8 μsec
Multiply:	33.3 μsec	41.1 μsec
Divide:	51.9 μsec	55.9 μsec
Fix:	5.9 μsec	8.8 μsec
Float:	9.8 μsec	24.5 μsec

Input/Output

Multilevel automatic priority interrupt: determined by interface location.
I/O channels in 2100A Computer: 14.
I/O channels in 2100A Computer plus 2155A Extender: 45.
I/O compatibility: HP 2114/2115/2116.

Memory Parity Check With Interrupt (Standard)

Priority: second highest priority interrupt (shared with Memory protect).
Operation: monitors all words read from Memory.
Interrupt: to trap cell for user written routine when parity error is detected.
Violation register: contains memory address where error occurred.

Memory Protect (Standard)

Priority: second highest priority interrupt (shared with Memory Parity).
Operation: initiated under program control; protects any amount of memory.
Fence register: set under program control; memory below fence is protected.
Violation register: contains memory address of violating instruction.

Writeable Control Store (Optional)

Words Available: 256 per module.
Maximum WCS Modules: 3 per 2100A.
Word Size: 24 bits.
Maximum Primary Entry Addresses: 16.
Microinstruction Time: 196 usec.

Physical*

Dimensions
- **Width:** 16¾″ with adaptors for mounting in 19″ rack.
- **Height:** 12¼″ (rack mounted).
- **Depth:** 2100A—26″ (23″ behind rack mounting ears); 2155A—23½″ (23″ behind rack mounting ears).

Weight
- **Minimum:** 91 lbs (41 kg).
- **Maximum:** 111 lbs (50 kg).

Electrical*

Power requirements: 115 V/230 V ±10%, 47.5 to 66 Hz, 800 watts maximum.

Environmental*

Operating temperature: 0° to 55°C (+32° to +131°F).
Relative humidity: to 95% at 40°C (104°F).
Ventilation
- **Intake:** rear panel.
- **Exhaust:** sides of front panel and cabinet.
- **Heat dissipation:** 2700 BTU/hr. maximum.

* Except as noted, applies to both the 2100A Computer and the 2155A I/O Extender.

DIGITAL TAPE RECORDER
OEM, On-Line, and Off-Line Applications
7970 Series

The 7970 Series Digital Magnetic Tape Units provide 800, 556, or 200 cpi NRZI and 1600 cpi phase-encoded electronics with the same superior operational and reliability characteristics usually associated with higher priced and more complex digital recorders. The 7970 was especially designed as a modular unit to enhance serviceability and reliability. All major transport assemblies are easily accessible for service and/or replacement, when required. The complete data electronics assembly is made up of plug-in type cards, neatly packaged in card cages within the 24-inch transport.

For the OEM

Model 7970B/C option configuration table (NRZI only)

Speed	9 Track			7 Track			7/9 Track
	RAW	R/O	BASE	RAW	R/O	BASE	R/O
10–20.9 ips	121	122	123	130	131	132	139
21–37.5 ips	Std	125	126	133	134	135	140
37.6–45 ips	127	128	129	136	137	138	141

Model 7970E option configuration table

Speed (ips)	9 Track						7/9 Track	
	PE Only				PE/NRZI		PE/NRZI	
	RAW Slave	RAW Master	R/O Slave	R/O Master	R/O Slave	R/O Master	R/O Slave	R/O Master
10-20.9	142	143	144	145	154	155	156	157
21-37.5	146	Std	148	149	158	159	160	161
37.6-45	150	151	152	153	162	163	164	165

ips = inches per second   cpi = characters per inch
NRZI = 800, 556, or 200 cpi   PE = 1600 cpi
RAW = Read After Write   R/O = Read Only   R/R = Read/Read
Master = initial PE unit   Slave = additional PE unit
Base = transport, less data electronics

For use with HP computers

For Hewlett-Packard computer users, the 7970 with interface kit and software kit may be used as a peripheral to configure a magnetic tape operating system. Systems available are:

12970A Magnetic Tape Subsystem

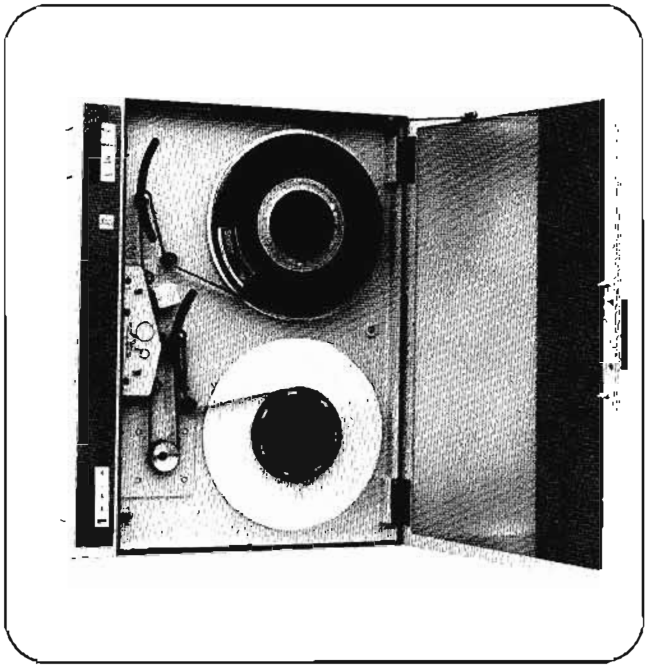
9-track NRZI, 800 CPI, 45 ips, read-after-write, IBM compatible, 115 volts, 60 Hz. **Includes:** 7970B Tape Drive, controller interface, head cleaner, 2400 ft. of tape, and operating system software.

Option 001: add 37.5 ips unit, delete 45 ips unit.
Option 002: add 25 ips unit, delete 45 ips unit.
Option 010: additional 45 ips unit, plus multi-unit cable, less controller and software.
Option 011: same as Option 010, but 37.5 ips unit.
Option 012: same as Option 010, but 25 ips unit.
Option 015: 230-volt, 50-Hz operation.

12971A Magnetic Tape Subsystem

7-track NRZI, 200/556/800 CPI, 45 ips, read-after-write, IBM compatible, 115 volts, 60 Hz. **Includes:** 7970B Tape Drive, controller interface, head cleaner, 2400 ft. of tape, and operating system software.

Options: same as those listed above for 12970A Subsystem.



12972A Magnetic Tape Subsystem

9-track Phase-Encoded (PE), 1600 CPI, 45 ips, read-after-write, IBM compatible, 115 volts, 60 Hz. **Includes:** 7970E Tape Drive, controller interface, head cleaner, 2400 ft. of tape, and operating system software.

Options: same as those listed above for 12970A Subsystem.

Note: a maximum of four tape drives on one controller.

Specifications*

Tape speed range: 10 to 45 ips.
Reel diameter: up to 10½″ (26.7 cm).
Tape: computer grade. **Width:** 0.5″. **Thickness:** 1.5 mils.
Tape tension: 8.5 ounces, nominal.
Tape format: IBM/ANSI compatible.
Rewind speed: 160 ips.
Start/stop travel: Read-After-Write: 0.187″ ±0.020″.

General specifications

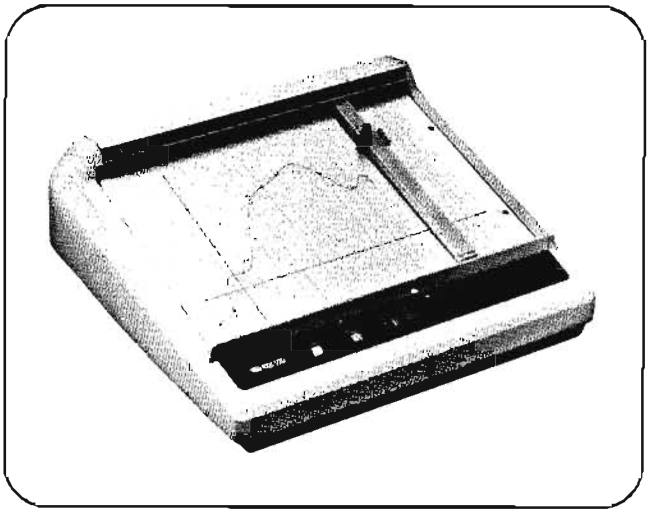
Power requirements: 115 or 230 (±10%) VAC, 48 to 440 Hz single phase. 400 VA, maximum (on high line).
Size: 24″ H, 19″ W, 15¾″ D (610 x 483 x 400 mm). Depth from mounting surface: 12″ (305 mm).
Weight: 140 lbs, maximum (63,5 kg).
Operating environment (hardware)
Ambient temperature: +32° to +131°F (0° to +55°C).
Relative humidity: 20% to 80%, noncondensing.
Altitude: 10,000 feet (3048 meters).
Price:** Model 7970B-Std, $4600. Model 7970E-Std, $8100.
Model 12970A Subsystem, $9900.
Model 12971A Subsystem, $10,600.
Model 12972A Subsystem, $13,400.

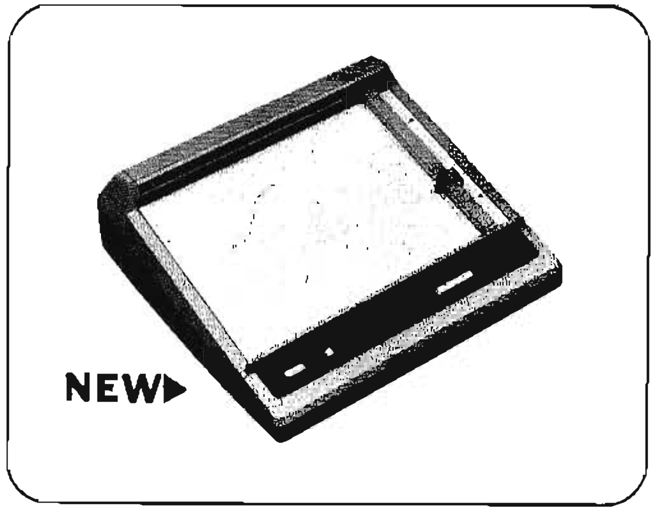
* For complete specifications and a list of accessories, request technical Data Sheet (7970B/C or 7970E).
** OEM prices and discount schedules are available.

COMPUTER GRAPHICS

Recorders, Printers, X-Y Plotters

Models 7200A, 7201A, 7202A, 7210A





7200A, 7201A, 7202A Graphic Plotters

These Hewlett-Packard Graphic Plotters offer the user an opportunity to produce graphs of computer-generated data. They operate with terminals which communicate with a computer directly or in a time sharing environment. Simple pneumonic commands, which can be generated by any computer in any language, are used to feed data and control the plotter.

The plotters connect directly to most communications terminals, and any of the newer terminals operating up to 30 characters/sec which utilize the EIA interface. Each features the same ease of use, and the same paper and pen systems as other Hewlett-Packard analog recorders (see page 20). Metric and English paper can be handled interchangeably.

Data is supplied in pairs of four-digit X and Y coordinates, so each new data point is totally defined and not dependent upon the accuracy of previous points. As true vector plotters, the 7200 series interpolate straight lines between data points, eliminating the need for the computer to generate intermediate points.

The plotters may be used on-line with a computer, or off-line with input directly from a paper or magnetic tape reader, a card reader, or even from a terminal keyboard. The 7200 Series operates in parallel with most terminals, they have the capability to silence the terminal as the plotter's data is being received.

Graphic plotters are particularly useful for the graphing of functions, curve fitting, regression analysis, transfer functions, probability distribution, shear and moment diagrams, checking of numerical control machine programs, or anything else that can be graphed. BASIC routines for curve and alphanumeric generation are available to be used on major time-sharing systems.

Models are available for 10 char/s ASCII code, for 14.9 char/s Correspondence, BCD or EBCD code, and a switchable speed unit accepts up to 30 char/s from terminals using EIA interface and ASCII code. The type of terminal must be specified on order; ask your local Hewlett-Packard Sales Office for complete specifications.

Prices:

Model 7200A (for teletypes, others at 10 char/s)	$3300
Model 7201A (for IBM 2741, A-J 841 or Datel 30)	$3300
Model 7202A (10, 15, 30 char/s switchable, EIA, ASCII)	$3575

Note: rentals begin at $200/mo; 2-year leases from $159 mo. OEM discounts available on purchases.

7210A Digital Plotter

The 7210A Digital Plotter is an output peripheral designed for use with computers and computer systems. The plotter's performance surpasses even that found in the traditional high overhead; high priced incremental plotters. Yet, the exceptional speed, resolution, and accuracy of the 7210A are available at the low cost normally associated with analog plotters.

Additionally, the 7210A can be added easily to either your computer or intelligent terminal. Accepting either Binary or BCD codes under full program control, the pen can make up to 20 moves per second at any angle. The 7210A contains an internal micro-processor that interpolates between data points. As a result, the data is interpreted very efficiently and the burden placed on the computer is minimal. The plotter will draw lines of any length and at any angle without computer interrupt during the move. A typical driver requires only 250 16-bit words of memory. Annotated graphs and title blocks can be provided by a driver of less than 1000 words. Any two points on the chart can be connected in one move with a pen speed of up to 12 inches/second (30,5 cm/sec) and a resolution up to 0.001 inches (0,025 mm).

Any sheet type graph paper, up to 11 x 17 inches (27,9 x 43,2 cm) in size and with or without preprinted grids, may be used.

Only end coordinate information is required to draw a line. The 7210A automatically computes all the intermediate points that are required to draw a stepless straight line—at any angle and any length. No computer interrupt is required during the move. Status lines allow the computer to fully monitor the plotter's status.

The two choices to define coordinate locations on the plotting area, selected under full program control, are:

Absolute Coordinates—All points on the chart are defined by absolute coordinate pairs, lines can be drawn any length and at any angle by specifying only the end coordinate. Each plotted point is independent of the accuracy of preceding points.

Relative Coordinates—Each new position is defined relative to the last. Ideal for relative position information in applications such as character generation and other repetitive operations.

Error detection is employed to eliminate plotting of improperly formatted and off-scale data. When absolute coordinates are used, no data is lost beyond the point in error.

The computer/plotter interface employs a "hand shake" interface typical in computer systems. The plotter can be driven with any computer or intelligent terminal that has an 8-, 12-, or 16-bit parallel word I/O channel. Logic is DTL and TTL compatible.

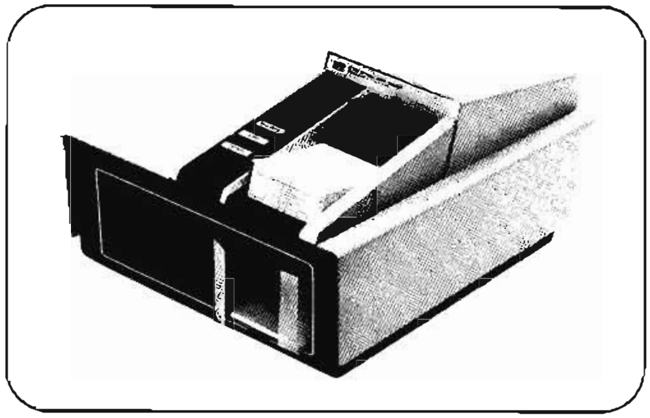
Price: Model 7210A	$3400
Option 001 (Interface for HP 2100 Series Computers)	$ 550

OPTICAL CARD READERS
Optical Mark/Sense Card Readers
Models 2761A, 2761B

The 2761 series Optical Mark Readers are low cost, desktop remote data-transmission terminals which read punched and marked tabulating cards. They are designed for use with standard telephone data sets in communication networks where limited information must be gathered from many sources, or where it is desirable to use the original document as direct input to the system, rather than paper tape, magnetic tape or manual entry from a keyboard. Each unit provides the convenience of automatic card feed for up to 300 cards.

The input is a standard tabulating card, with pre-printed clock marks, coded by marking lines through pre-printed boxes with a regular soft lead pencil. Up to 80 columns of alphanumeric information may be marked or punched on a single card. Marking and punching may be intermixed on the same card.

Since the tab cards can be hand marked, and are read directly as marked, keypunch operations are bypassed. Cards can be pre-punched or pre-printed with identifiers and routine information for turn-around applications, reducing the amount of hand-entered data, and assuring correct identification of the turn-around document. Immediate data transmission can speed the input of orders, payroll charges, inventory entries, shipments, billings and similar operating data to a central processor. The Optical Mark Reader is easy to use, and operation requires no special skills or training.



The 2761A is designed to read data directly into a computer or other data acquisition system in 12-bit parallel form at rates up to 250 cards/min. The 2761B generates a bit-serial ASCII code output from either the Hollerith punch format or the Hewlett-Packard Dial Code format. Data rates of 10, 30, or 105 char/s are available by option.

Specifications

Performance specifications—2761A

Data Rate: 200 cards per minute externally controlled, or 250 cards per minute when operated at the internal read rate. Maximum of 80 marked or punched columns per card, exact requirements being determined by computer software. 80 column cards: 455 char/sec ±10%. 40 column cards: 227 char/sec ±10%.

Card Timing: Minimum interval feed command to first data; 90 +40 −10 msec.
Card Reading Time; 190 ±10 msec.
Time between cards: feed control, 90 −10 +40 msec, no control, 50 ±25 msec.

Performance specifications—2761B

Code Capacity: Recognizes 64 different characters using either Hollerith or Dial code (specified by option choice).

Code Transition: Translates character-serial Hollerith or Dial codes to bit-serial transmission code (ASCII). All cards must have clock marks.

Parity: Generates and transmits even parity for use by receiving terminal.

Data Rates: Either 10, 30, or 105 characters/second (specified by option choice).

Interface Connector: Cinch or Cannon DBM-25S on rear panel.

Data Set Interface: Data Set Interface is compatible with requirements of EIA Standard RS-232C.

General specifications

Card Dimensions: Standard 3¼ by 7⅜ inch tab cards.

Hopper Capacities: Input hopper for 300 cards. Output hopper capacity of 300 cards.

Environmental Conditions:
Operating temperatures: 0° to 55°C (32° to 131°F).
Relative humidity: 95% at 40°C (not applicable to cards).
Storage temperatures: −40° to +75°C (−40° to +167°F).

Input Power Required: 115V ±10%, 60 Hz, ±5%, 130 W or 230 V ±10%, 50 Hz ±50%, 130 W, single phase.

Weight: Net: 28 lb (12,7 kg); shipping: 37 lb (16,8 kg).

Dimensions: Reader is fully enclosed for desk-top use. 12¾ inches (324 mm) wide by 20 inches deep (508 mm) including cable clearances, and 9¼ inches (235 mm) high.

Prices

Model 2761A (12-bit parallel output)	$2950
Model 2761B (64-character Hollerith Code)	$3300
Model 2761B (64-character Dial Code)	$3350

Note: OEM discounts available.

Options

2761A:

Power	Option
115 V, 60 Hz	007
230 V, 50 Hz	008

2761B:

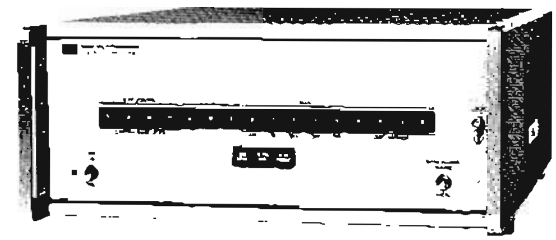
(Char/Sec)	Power	Option Number: Up to 40 Col. Density	Option Number: Up to 80 Col. Density
10	115 V, 60 Hz	002	005
30		003	006
105		004	009
10	230 V, 50 Hz	022	025
30		023	026
105		024	029

Automatic Stop: Hopper empty/stacker full switch Opt 036.

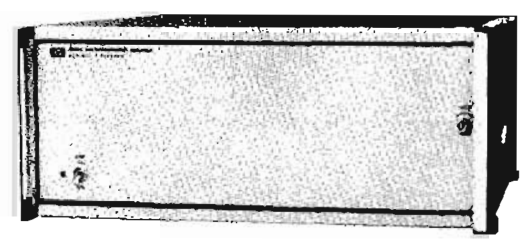
MULTIPROGRAMMER

Convenient and flexible systems interface

Models 6940A, 6941A



6940A



6941A

Description

The role of minicomputers in real-time system applications is often limited by the computer's inability to control and monitor large numbers and varied types of devices at reasonable cost. In addition, many devices used in automatic systems require control signals in forms not normally available as computer outputs.

The 6490A/6941A Multiprogrammer overcomes these limitations by providing a low-cost bidirectional data link between a single 16-bit computer I/O channel and up to 240 individually addressable, plug-in card slots, each with a 12-bit I/O capability. Input-type plug-in cards accept inputs in the form of contact closures and various logic levels, while output cards provide programmable outputs in the form of resistance, voltage, current, contact closures, and logic levels.

One Multiprogrammer (6940A) mainframe and up to 15 Extender (6941A) mainframes can be operated from a single computer I/O channel. The 6940A mainframe is connected to the controlling computer through a computer interface card and an input cable. The first 6941A mainframe is connected to the 6940A mainframe through a chaining cable, and each additional 6941A mainframe is connected to the previous one through an identical cable. Each mainframe (Multiprogrammer or Extender) contains 15 slots into which can be plugged any combination of input and output cards.

Flexibility and expandability are bonuses of the Multiprogrammer's modular design. The wide variety of Multiprogrammer plug-in cards allow a system designer to use standard mainframes and plug-in cards in configuring a custom system to satisfy a specific set of requirements. The final product is thus a custom system with the reliability and performance of a factory-built instrument. Additions or modifications to the finished system can be accomplished easily at any time, without changes in operating software, by simply adding more plug-in cards and Extender mainframes.

The Multiprogrammer mainframes and plug-in cards have been designed to function together as an integrated system possessing many built-in features of significant importance in the design and implementation of real-time computer-controlled systems. Among these features are:

- Digital data storage on all plug-in cards to reduce computer overhead.
- The ability to program specific output cards individually or in selected groups.
- The generation of a computer interrupt when digital lines being sensed change state.
- The program selection of data transfer rates between the computer and the Multiprogrammer to either proceed at the maximum possible rate or be governed by the particular device being controlled by each card.
- The ability to program all plug-in cards to a safe state in case of system alarm.
- A front-panel switch register on the 6940A mainframe which permits manual control of the system and thus enhances serviceability.
- All outputs go to "zero state" in case of power failure.

Applications for the Multiprogrammer exist wherever one to several thousand devices must be independently controlled or monitored from a single computer I/O channel or other single source of digital data.

Common specifications

Input/Output Card Positions: Maximum of 15 plug-in input or output cards per mainframe. Side-hinged front panel provides access to card slots.

Mainframe Data Connectors: Two 50-contact, rear-mounted, female ribbon connectors.

Data Transfer Rate: 100 k word/sec. guaranteed minimum.

Maximum Data Resolution: 12 bits.

Accessories Furnished: Data Input Plug, Rack Mounting Kit, PC Board Extender Card.

Cooling: Natural convection.

Temperature: 0 to +55°C operating, −40 to +75°C storage.

Dimensions: 16.75" W x 6.78" H x 21.25" D (42,54 x 17,22 x 53,98 cm).

Power: 115 or 230 Vac ±10%, 48 to 440 Hz 230 watts.

Model 6940A Specifications

Front Panel Controls: Power ON/OFF switch and indicator lamp, REMOTE/LOCAL switch for selecting computer or manual control, 19 proximity switches for manual data entry and control.

Interfacing: A 6940A mainframe equipped with the standard interface card is designed to interface with binary sources employing TTL or DTL microcircuit logic. An interface kit (14543A) containing the necessary hardware and software to interface the 6940A with any Hewlett-Packard computer is available. An optional custom interface card (69340A) is also available to satisfy customer requirements different from those of the standard card.

Weight: 35.0 lbs. (15,9 kg.) net, 43.0 lbs. (19,5 kg.) shipping.

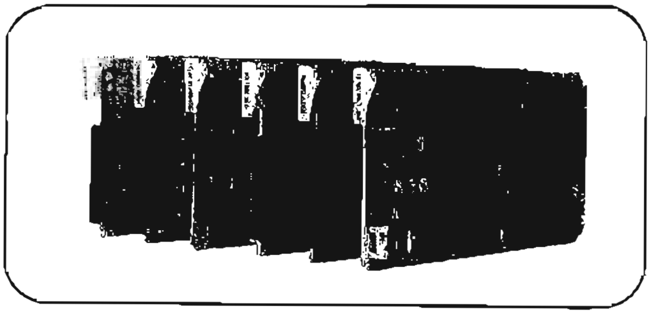
Price: $1500.

Model 6941A Specifications

Front Panel Controls: Power ON/OFF switch and indicator lamp.

Weight: 33.5 lbs. (15,2 kg.) net, 40.3 lbs. (18,3 kg.) shipping.

Price: $900.



Input/Output cards

Series Element Output Card, Model 69500A: allows customer to select and load own series-adding elements. Can be field-strapped to provide one 12-element or two, independent, 6-element output channels. **Price,** $300.

Parallel Element Output Card, Model 69360A: provides programmable analog output proportional to the parallel sum of user-selected resistive or reactive elements. Can be field-strapped to provide one 12-element or two, independent, 6-element output channels. **Price,** $300.

Resistance Output Cards, Models 69501A-69504A: provides a single 12-bit resistance programming channel; the programming coefficients of these models are compatible with Hewlett-Packard programmable power supplies equipped with option 040. **Price,** $345.

Resistance Output Cards, Models 69510A-69513A: provides two 6-bit resistance programming channels; these models are designed for programming the current limit of Hewlett-Packard programmable power supplies equipped with option 040. **Price,** $345.

High Speed D/A Converter Card, Model 69321B: provides a high speed, bipolar output voltage that is the analog of the digital input data to the card. Output range is from -10.240 to $+10.235$ V, at 0-5 mA. Programming speed is 50 μsec maximum to within 5 mV of final value. (69351A also required.) **Price,** $385.

Current D/A Converter Card, Model 69370A: provides a high speed, constant current output that is the analog of the digital input data to the card. Output range is 0 to $+20.470$ mA, at 0-11 Vdc. Programming speed is 100 μsec maximum to 10 μA of final value. (69351A also required.) **Price,** $350.

Relay Register Card, Model 69330A: provides 12 separate form A (SPST, normally open) mercury-wetted contact outputs that reflect the status of 12 programmed data bits. Includes gate/flag circuits for exchange of control signals with user's device. **Price,** $370.

Relay Output/Readback Card, Model 69433A: provides 12 separate form A (SPST, normally open) mercury-wetted contact outputs. Also supplies 12 input data lines that can be read by the computer and which indicate the relay coil voltage status. **Price,** $430.

TTL Output Card, Model 69331A: provides programmed microcircuit logic level outputs on 12 separate output lines. Card includes gate/flag circuits for exchange of control signals with user's device. **Price,** $200.

Breadboard Output Card, Model 69380A: allows customer to design and build a custom analog or digital output card. Card includes basic address, storage, and control signal buffer circuits. **Price,** $75.

Input cards

Digital Input Card, Model 69431A: monitors 12 bits of TTL, DTL, or contact closure data from user's device. Card includes gate/flag circuits for exchange of control signals with user's device. Outputs to computer reflect the status of 12 input bits. **Price,** $200.

Isolated Digital Input Card, Model 69430A: monitors 12 bits of input data from user's device. All input lines are isolated from one another and from the multiprogrammer power supply. Eight options of the card are available to accommodate either ground-true or positive-true logic sense inputs and a wide range of input levels. **Price,** $200.

Event Sense Card, Model 69434A: compares the magnitude of an external 12-bit input word with a stored reference word and generates a computer interrupt for any of four conditions, depending on the placement of a jumper on the card. The four possible conditions are: In = Ref, In $\neq$ Ref, In > Ref, In < Ref. The reference word is loaded from the computer. Both the input and reference words can be read back to the computer. **Price,** $300.

Breadboard Input Card, Model 69480A: allows customer to design and build a custom input card. Card includes basic address and readback circuits. **Price,** $75.

Hardware accessories

Custom Interface Card, Model 69340A: allows interfacing the 6940A with programming sources having non-standard logic level, logic sense, or termination specifications. **Price,** $125.

6940A Interface Kit, Model 14543A: contains hardware and software for interfacing the 6940A with any Hewlett-Packard computer. **Price,** $1250.

Main Input Cable Assembly, Model 14540A: connects the 6940A to the 12566A Microcircuit Interface I/O Card. **Price,** $150.

Chaining Cable Assembly, Model 14541A: connects 6940A to 6941A, and 6941A's to other 6941A's. **Price,** $150.

Voltage Regulator Card, Model 69351A: required in every 6940A or 6941A mainframe containing High Speed Voltage D/A Converter or Current D/A Converter Cards. **Price,** $125.

Software accessories for use with HP computers

14904A: this driver controls 6940A/6941A Multiprogrammer Systems under the basic control system (BCS). It performs most general purpose software functions required for efficient operation of the Multiprogrammer.

Prices: 14904A -B01 (binary tape), $10; -S01 (source tape), $30; -L01 (program listing), $5; -A01 (includes B01, S01, and L01), $45; -D00 (instruction manual), $2.

14905A: this program provides a post-installation check of 6940A/6941A Systems using Interface Kit 14543A.

Prices: 14905A -B01, $10; -S01, $20; -L00, $5; -A01, $35; -D00, $2.

14907A: this driver controls Multiprogrammer Systems via a Real Time Executive (RTE) system.

Prices: 14907A -B01, $10; -S01, $15; -L00, $5; -A01, $30; -D00, $2.

14909A: this program establishes 24000A BASIC and 20392A BASIC subroutines which control 6940A/6941A Multiprogrammer Systems.

Prices: 14909A -B01, $10; -S01, $15; -L00, $5; -A01, $30; -D01, $2.

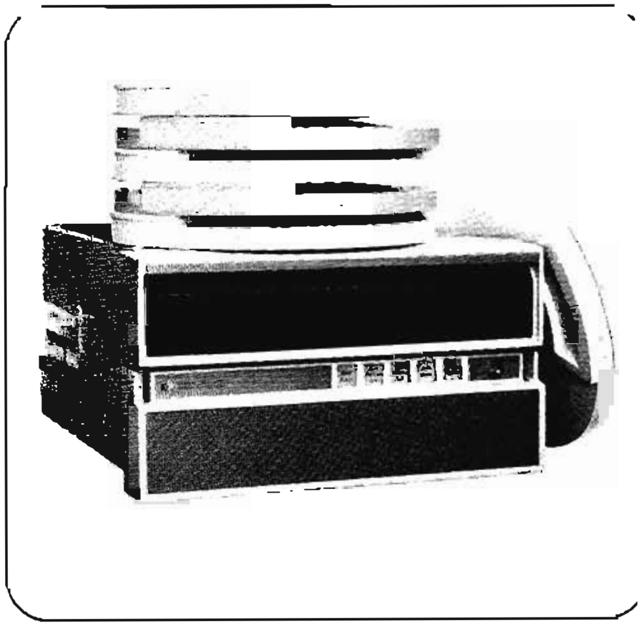
14913A: this driver controls 6940A/6941A Multiprogrammer systems via DOS or DOSM operating systems.

Prices: 14913A -B01, $10; -S01, $15; -L00, $5; -A01, $30; -D00, $2.

DISC DRIVE

Moving-head, front-loading

7900A and 7901A



The Model 7900A Disc Drive is a random-access moving-head dual-disc memory device, compactly designed for use as a peripheral unit in small and medium sized computer systems. It uses a permanent disc and a removable disc cartridge, both with a packing density of 2200 bits/inch. Each disc surface contains 203 tracks, divided into 24 sectors, and each sector is capable of storing approximately 6,000 data bytes. With four disc surfaces, data capacity totals approximately 5 million bytes. And using removable cartridges provides an unlimited amount of shelf storage.

A photo-optical positioning system, working in conjunction with a velocity transducer and a powerful voice-coil-driven actuator, provides exceptionally fast and precise head positioning. In fact, the actuator moves the head-carriage assembly from track to track in less than 7 milliseconds, and completely across all the tracks on the disc in less than 55 milliseconds. Average access time is less than 30 milliseconds.

The fixed-removable configuration, plus very rapid cartridge changing and a fast data transfer rate, provides a capability for making a backup copy of an on-line data base or system. The large on-line capacity allows storing and maintaining large data or program files.

The accuracy of positioning allows collecting or producing files on a disc cartridge on one 7900A Disc Drive and then reading these files on any other 7900A or 7901A, even if it is operating in a totally different environment.

Other significant standard features of the 7900A Disc Drive include Write Protection on either disc and use of up to four drives per controller. It also has an absolute air filtration system that minimizes environmental contamination and maintains positive pressure in the drive enclosure during cartridge changing.

Operating power for the 7900A is supplied by the Model 13215A Disc Power Supply. It provides three regulated, constant dc voltages; two unregulated dc voltages; and the ac voltage to operate the disc drive ac motors.

New Model 7901A Disc Drive

The Model 7901A Disc Drive is essentially a single-disc version of the 7900A. Principal differences are an integral power supply and only one removable disc cartridge. The two drives are completely compatible. That is, recoded discs can be interchanged between the two drives without any loss of data or performance. This makes the 7901A extremely valuable as an add-on drive for the 7900A.

However, a high-quality, low-cost, complete disc operating system can be built around the 7901A. This provides a full-capability system that can be easily changed by removing a single disc cartridge or by adding up to three more disc drives to the same controller. In fact, a system can include any combination of four 7900A's and 7901A's on the same controller.

OEM configurations and quantity discounts are available. Contact your local Hewlett-Packard sales and service office.

Specifications*

Access times

Head positioning (includes settling):

Track-to-track: <7 milliseconds.

Average move (67 tracks): <30 milliseconds.

Maximum move (203 tracks): <55 milliseconds.

Rotational delay

Average (½ revolution): 12.5 milliseconds.

Maximum (1 revolution): 25.0 milliseconds.

Data transfer rate: 2.5 million bits/second (312,000 8-bit bytes/second.

General specifications

Dimensions: 10½" H, 19" W, 25⅝" D (267 x 483 x 651 mm). Depth from mounting surface: 22-15/16" (583 mm).

Weight: 117 pounds (53,1 kg).

Environment: operates within specifications over the following ranges:

Temperature: operating: +50° to +104°F (+10° to +40°C); nonoperating: −4° to +149°F (−20° to +65°C).

Humidity: up to 80%, noncondensing.

Attitude (pitch and roll): ±30° about either axis.

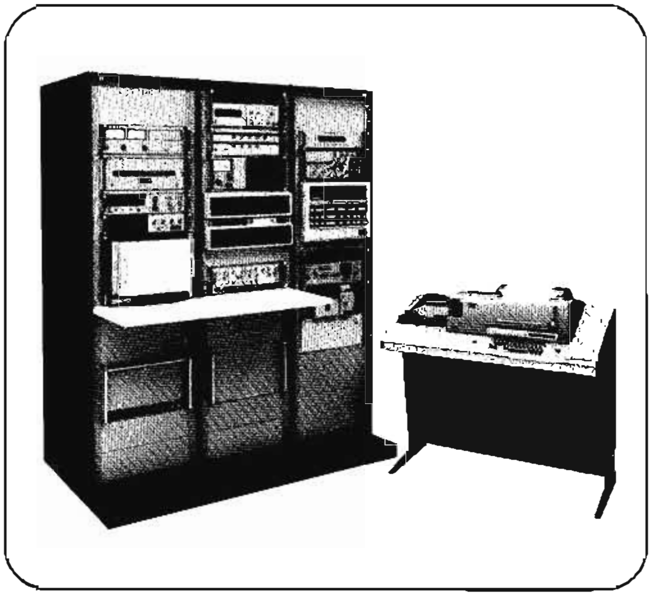
Air filtration: absolute air filter; volume is 65 CFM.

Accessories available: 12869A Disc Cartridge; 13211A Rack Mounting Kit; 13219A Disc Service Unit.

Price:** 7900A: including 13215A Power Supply and 12869A Disc Cartridge, $9975. 7901A: including 12869A Disc Cartridge, $5900.

*These basic specifications apply essentially to both drives. For complete specifications and options, request technical data sheet (7900A or 7901A).

**OEM prices and discount schedules are available.



One of the Many Configurations of an HP 9500 Series Automatic Test System.

The HP 9500 Series Automatic Test Systems offer a highly cost-effective solution to the testing requirements of modern electronic equipment. Hewlett-Packard automatic test systems encompass a wide range of testing capability, from individual circuit modules and sub-assemblies to highly complex avionic systems.

The major system elements are a controller, plus stimulus, switching, and measurement subsystems. Individual instruments comprising these systems are determined by the specific testing requirements. Off-the-shelf commercially available instruments are used wherever possible in the subsystems. The overall concept further includes plug-in hardware interfacing plus an easily-learned programming language that is able to handle present-day programmable instruments and those anticipated in the future.

A highly significant factor contributing to the cost-effectiveness of these automatic test systems is that they do not require a full-time programmer-operator in attendance; rather, they are truly designed for operation by test technicians, or even production workers. Every system is equipped with a control panel which completely eliminates the need for the test operator to handle any computer switches. A choice of software operating systems—either tape-based or disc-based—offers further operator convenience and system capabilities. The test-oriented paper tape system (TOPTS), for example, merely requires that a test-program tape be loaded into the computer to begin a test sequence. A more flexible system, with many more operational features, is the test-oriented disc system (TODS). A TODS system provides virtually unlimited program/data storage and, combined with the system control panel, offers test program and data retrieval by pushbutton selection.

In general, testing done by the 9500 systems falls into the categories of: analog-only testing, analog/digital testing, or digital-only testing. The photo shows an analog/digital system, while the illustration shows a typical analog-only system. Digital systems perform static functional testing. They are considerably simpler in hardware makeup, consisting essentially of a Hewlett-Packard digital test unit and its power supplies, reference supplies, interface panel, and a controller with tape reader and disc memory.

Flexible, test-oriented software

Hewlett-Packard has standardized on HP ATS BASIC as the programming language for the entire family of test systems in the 9500 Series. Particularly important is the fact that it is an easily learned and powerful test programming language, offering all the computational capabilities needed for automatic testing, along with instrument control and timing statements. Because there are only a few rules to remember, HP ATS BASIC can be learned in a few hours, and be used effectively to write test programs within two or three days.

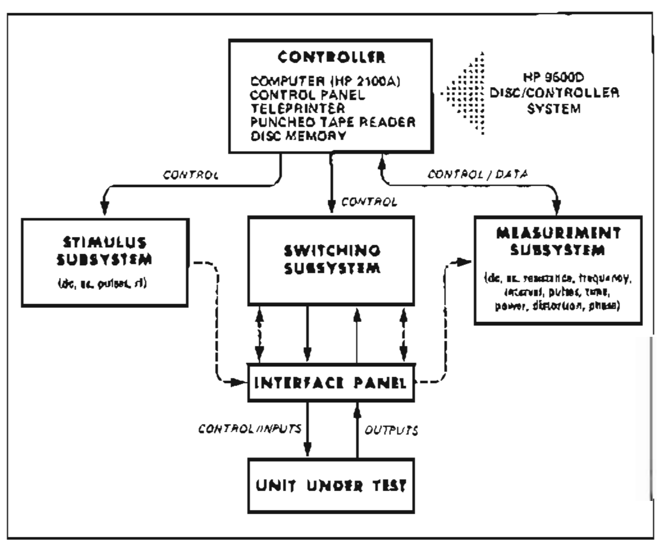
The TOPTS system offers economical test automation for applications where the frequency of changeover from one type of unit under test (UUT) to another type is low.

Where many different types of UUTs are involved and where the types of UUTs are changed frequently, TODS avoids the need for loading tape for each program, since programs may be loaded from the disc into core memory by an operator command. The disc system also permits use of test programs of virtually unlimited length, since programs may be segmented and the segments automatically loaded into core memory for execution. An advantage of the modular 9500 system is that a paper tape TOPTS system can be upgraded to a disc-based TODS system at any time.

Special capabilities

The inherent flexibility and modular construction of the 9500 Series make the overall system easily expandable to handle very large testing requirements encompassing many types of stimuli and measurements. Hewlett-Packard welcomes the opportunity to offer expert engineering assistance to solve your testing needs.

A comprehensive set of literature, including an easy-to-follow selection guide, describing the 9500 Series is available from Hewlett-Packard field sales offices.

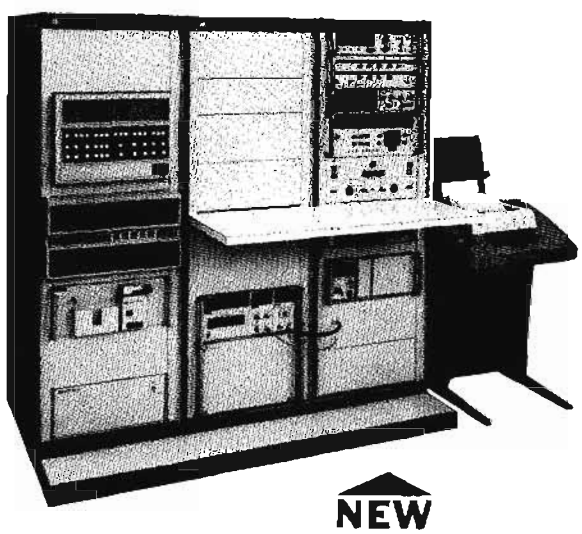


HP 95000 Automatic Test System Overall Concept. (HP 9500B with Paper Tape Controller is also available. Digital Test Capability can be added to Both Systems.)

TRANSCEIVER TEST SYSTEMS

Test AM and FM communications equipment

9540 Series



The HP 9540D Disc-Based Transceiver Test System

The HP 9540 Series Transceiver Test Systems provide a fast, accurate, and highly repetitive means of testing communications receivers, transmitters, power supplies, as well as complete two-way radio sets. These computer-controlled systems perform all the testing requirements for AM and FM two-way radios operating from 25 MHz to 1300 MHz. The systems are particularly useful for production and final assembly testing applications, and for the testing needs of maintenance labs and service shops.

A direct outgrowth of the HP 9500 family of automatic test systems, the 9540 Series incorporate many features of the 9500 Series. These include a choice of software operating systems—either TOPTS, the paper-tape-based system or TODS, the disc-based system. Each system also includes a control panel which completely eliminates the need for the test operator to handle any computer switches. Particularly significant, from the cost-effectiveness standpoint, is the fact that these systems do not require a full-time programmer-operator in attendance; rather, they are truly designed for operation by test technicians, or even production workers. In operation, the 9540 displays all operator instructions such as "enter serial no.", "switch frequency 150.1 MHz," etc. Also, tests can be repeated at new frequencies and amplitudes, desired results can be calculated from measured values, the system can check itself for malfunctions, show whether the unit under test has passed or failed, and repeat these functions accurately every time. In addition to a comprehensive set of technical documentation, Hewlett-Packard also supplies, with each system, several sample test programs (measuring receiver sensitivity, audio distortion, *etc.*) as a guide to assist in writing programs for your specific needs.

HP 9540 Series Test Capabilities

Transmitter tests	
Carrier Power Output	FM Deviation
Carrier Frequency and Stability	Audio Distortion
AM Hum and Noise	Audio Frequency Response
FM Hum and Noise	Audio Sensitivity
AM Modulation	
Receiver tests	
SINAD Sensitivity	Audio Frequency Response
Quieting Sensitivity	FM Modulation Acceptance Bandwidth
Audio Sensitivity	Hum and Noise Levels
Squelch Operation	Image Channel Rejection
Audio Power Output	IF Rejection
Audio Distortion	
Modules & subassemblies	
Modulators and Subassemblies	Audio Amplifiers
Local Oscillators	Filters
Frequency Synthesizers	Selective Signaling Circuits
IF Amplifiers	Power Supplies

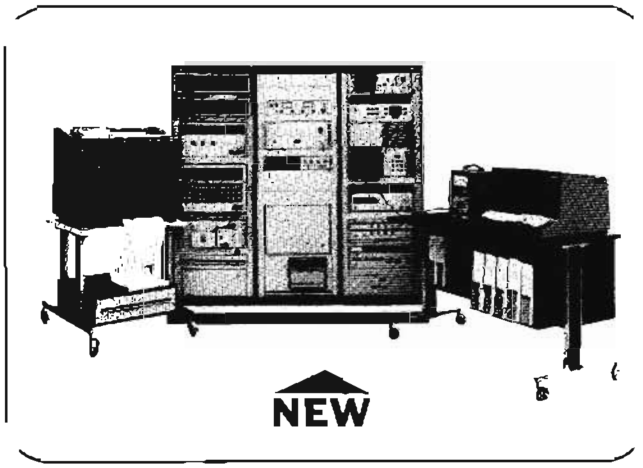
Flexible, Modular Design

The overall 9540 system follows a modular design philosophy, using subsystems as building blocks. Off-the-shelf commercially available instruments are used wherever possible, thus making the system easily expandable to handle future needs. Major instruments comprising a 9540 system are organized into three functional subsystems: (1) stimulus instruments (frequency synthesizers) for inputs to the unit under test (UUT), (2) measurement instruments (digital voltmeter, frequency counter, power meter, and RF detector) for outputs of the UUT, and (3) switching components (modular switch) to route input and output signals. In addition to the subsystem elements, each system includes a computer-controller with peripherals, to operate the system.

Presently, two versions of the 9540 Series test systems are available, differing only in the controller used. The 9540B is a tape-based system utilizing a controller which consists of an HP 2100A Computer, control panel, high-speed punched tape input (reader), tape punch, and a system teleprinter. The HP 9540D is a disc system which includes the same basic elements plus a dual magnetic disc memory which provides an additional 2.5 million words of auxiliary memory. One of the two disc packs is removable, which offers virtually unlimited program/data storage capacity. The permanent disc keeps a running file on all stored information, thus easing the programmer's task of locating specific data.

Expert Assistance Available

Hewlett-Packard welcomes the opportunity to offer expert engineering assistance to solve your communications equipment testing needs. A brochure, describing the HP 9540 Series Transceiver Test Systems in more detail, is available from Hewlett-Packard field sales offices.



HP 9551D Automatic Calibration System (expanded Version) with CRT Readout and Hand-Held Control on Table. Optional Line Printer is at Left.

The HP 9550 Series Instrument Calibration Systems bring to the calibration laboratory a cost-effective solution to calibrating the myriad of complex instruments in use today. At the same time, these automated systems effectively reduce the costs of training skilled technicians, while increasing efficiency by helping to solve present and future workloads and other lab management problems.

Presently, two versions of the calibration systems are available, differing only in the levels of capability. Both systems incorporate a wide variety of calibration quality instruments, easily recognized by those involved in cal lab as required for calibration purposes. The HP 9551D is a basic system for calibrating a wide variety of passive meters, multimeters, electronic meters (voltage, current, VSWR, power, etc.), differential voltmeters, digital voltmeters, frequency counters, and oscilloscopes along with their plug-ins and amplifiers. The HP 9550D is an expanded version which will calibrate all of the foregoing plus signal sources and generators, oscillators, pulse generators, and function generators.

User program interchange

Industry has long recognized the fact that where applications software must be developed on an individual basis, the costs can easily exceed the costs of the hardware system itself. For this reason, Hewlett-Packard has established a library of applications programs for system users. The library will contain both user-furnished instrument calibration programs and Hewlett-Packard certified programs for the calibration of commonly-used instruments. Presently, 46 programs are to be available. This is an ongoing effort under which additional programs will be made available in the future.

Easily learned programming

The automatic calibration systems incorporate the same programming language as the HP 9500 Automatic Test Systems—HP ATS BASIC. The ease of learning aspect of HP ATS BASIC makes it the ideal programming language for a cal lab, because programming is done by the lab's test engineers and test technicians. Local programming gives the cal lab a great deal of flexibility in upgrading or converting existing programs to calibrate new instruments.

Adding to the ease of programming is a test-oriented disc system (TODS)—an operating system supplied with both the HP 9550D and the HP 9551D systems. This is the same software system supplied with the HP 9500 Series systems which incorporate a dual disc magnetic memory. One disc is interchangeable, offering virtually unlimited program/data storage capacity. The operating system keeps a running file on all calibration programs and other stored data, thus easing the operator's task of locating specific data.

Calibrating a meter

The automatic system uses recommended calibration procedures from instrument instruction manuals as the guidelines. The power of the computer systems, however, allows these procedures to be adapted to the use of innovative techniques which substantially reduce calibration times. As a typical example, the HP 412A Multifunction Meter requires that the operator must switch through 13 range positions for 3 different functions of volts, milliamps, and ohms, then interpret the full-scale indication and decide whether the instrument meets specifications. Without the automatic system much of the operator's time is spent reading the meter (with resultant human-interpretation error).

The automatic calibration system, on the other hand, requires that only one visual interpretation be made at each of the meter's cardinal positions (10%, 20%, 30%, etc.). At each of the ten points, the operator manually adjusts the stimulus and aligns the meter needle to the exact cardinal point. At each point, the system characterizes the meter movement in terms of the electrical output needed for a particular mechanical deflection. Now, the operator follows instructions shown on the CRT display to switch ranges and functions. The system "reads" the meter movement electrically. The CRT then displays "test failed" if that particular test does not agree with the limits stored in memory, or jumps to the next test if the values are valid.

In the final analysis, this relatively simple technique involves a change in the calibration procedure itself by minimizing operator interaction with the test, resulting in a savings in elapsed time and a significant reduction in overall errors.

Future expansion capabilities

The inherent flexibility and modular construction of the automatic calibration systems make it possible to add peripherals and instrumentation to the "starter system" as future needs require. Already, the trends in automated instrument calibration systems are indicating that, for maximum efficiency, cal labs would be divided into multiple work stations with system hardware dedicated to specialized functional areas such as analog meters, scopes, or microwave equipment. Architecture for such systems would include a central computer for peripheral sharing, mass file storage, and a management data bank, all connected to a small computer at each work station. The HP 9550 Series Instrument Calibration Systems are capable of being upgraded to this type of operation. Contact Hewlett-Packard for expert engineering assistance to solve your calibration laboratory measurement and data management problems.

COMPUTER SYSTEMS
For Data Acquisition and Control
9600 Series

Hewlett-Packard has for many years been an industry leader in the development, manufacture, and supply of sensor-based, computer-automated data acquisition and control systems.

Hewlett-Packard employs a modular concept in configuring the wide range of data acquisition and control capability offered. Modularity in the systems starts with the computer (HP 2100A) memory capacity, which is plug-in expandable from 4,096 words to 32,768 words. Input/output capacity of the system computer is expandable from the basic 14 channels in the mainframe to 45 channels with the addition of an I/O extender. Modularity goes beyond the computer to encompass a selection of 8 different data acquisition (analog-to-digital) subsystems, 15 peripheral devices, 8 different general purpose interfaces, a choice of 3 different software operating systems, and 3 different computer programming languages. These subsystems and peripherals are fully hardware and software compatible, so they are readily assembled into a system that satisfies present measuring needs, and yet can be easily expanded to suit future requirements.

Applications of computerized systems

In research, development, and production applications, for example, a Hewlett-Packard computerized system: (a) coordinates the stimulus and measurement actions of the instruments involved in various experiments, (b) acquires and converts analog data from physical sensors to digital form, (c) corrects the data for non-linearity and offsets, and multiplies it by known factors to convert it to meaningful scientific units, (d) calculates consequent results, (e) performs statistical analyses, and (f) logs or displays results.

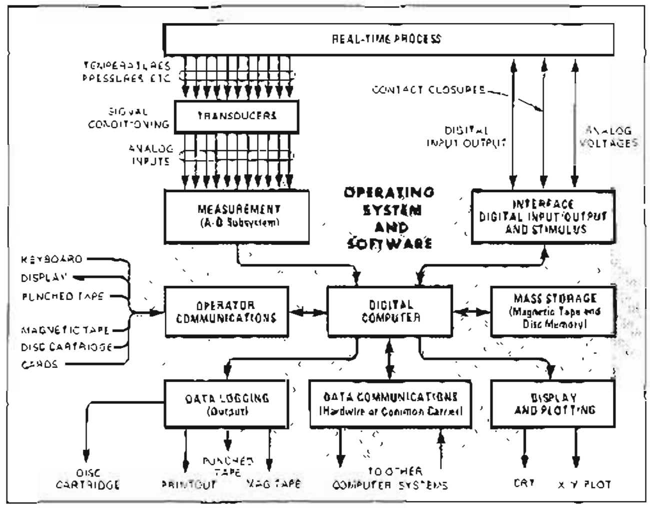
Systems involving remote test sites are easily handled by tieing the sites into one unified distributed system by means of Hewlett-Packard data communications interfaces. Here a small computer system at each remote site performs most of the data acquisition and control functions and concentrates the data prior to transmission to a central computer, up to nearly two miles distant over simple hardware lines. Date phone interfaces can be used for greater distances.

System concept

Major system functions of a Hewlett-Packard system for data acquisition and control are shown in the diagram. Central element of the system is an HP 2100A Digital Computer. For multiplexing and digitizing analog input signals, a choice of standard subsystems provides high-resolution (dc) measurements at rates to 40 channels/second and high-speed measurements at rates to 100,000 samples/second. Other instruments are available for ac voltage measurements, high frequency counting, dc stimulus output, etc.

Interfacing with users' equipment

Many versions of bi-directional registers are available to interface digital-type user-furnished equipment to the system computer. Also available are hard-contact relay output registers for controlling external circuits and digital-to-analog converters for controlling analog-type devices. These interface registers and converters are contained on single cards which plug into the Hewlett-Packard computer. The computer's large input/output capacity allows many external devices to be monitored and controlled, over and above the measuring instruments and peripherals comprising the basic system.



System software

Hewlett-Packard computerized data acquisition and control systems are supported by a very comprehensive catalog of software. Three software operating systems—Basic Control System (BCS), Data Acquisition and Control Executive (DACE), and Real Time Executive (RTE)—provide an operational framework for data acquisition and control in real-time. The systems are programmed in Hewlett-Packard Assembly language, FORTRAN, or ALGOL.

The BCS provides relocation and linking services, thus simplifying preparation of user-programs and their configuration into the overall system. BCS is an interrupt-driven system that allows measurements, processing, and logging of results to take place concurrently.

The DACE is a clock-driven system designed for applications in which operation of the data acquisition system must be scheduled in real-time. Data acquisition and control programs are subdivided into "tasks" such as measurements, calculations, limit checking, logging of data, and updating of control commands. The DACE enables cueing (or deleting) of tasks at desired elapsed times. Task constants and parameters can be examined and modified without recompiling. Within a task, transducer readings can be converted to engineering units and linearized; sampling rates can be related to actual values measured and changed as a signal strays beyond limits; other tasks can be initiated, depending on results obtained in the current task.

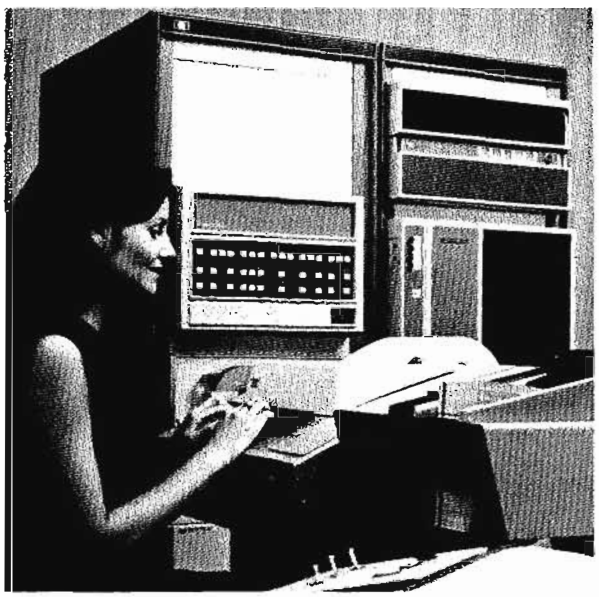
The RTE is a clock-and-interrupt-driven system providing multiprogramming, foreground-background operation with priority scheduling, interrupt handling, and program load-and-go capabilities. Under RTE control several real-time foreground programs, e.g., multiple test stations, can run concurrently with general-purpose background programs. (Foreground and background refer to areas of core.) While data are being taken on demand, processed, and output in the foreground, the time not needed for real-time processing may be used for program development in background without interrupting the running programs.

Additional information on the 9600 Series systems is provided in a brochure, "Computer Systems for Data Acquisition and Control." The brochure, plus an easy-to-understand Selection Guide are available from Hewlett-Packard Field Sales Offices.

DISC OPERATING SYSTEM

A small computing system with a lot of punch

Model 2120A



2120A

Description

The HP 2120 minisystem offers you maximum performance for your computing dollar. It gets its power from the marriage of hardware and software. It combines Hewlett-Packard's versatile 2100A minicomputer, the fast 7901A 2.5 megabyte disc, a teletype console, paper tape reader, and its unique disc operating system that makes the whole system tick. Best of all, it won't hurt your pocketbook either. 2120 minisystems start at less than $27,000.

The *2100A Digital Computer* is the heart of the 2120 minisystem. It has a submicrosecond memory, uses the latest in MSI/LSI technology, and is controlled by a microprogrammed read only memory. The system uses a basic 8K of memory and can be expanded to 32K. Standard features are direct memory access, hardware multiply/divide, memory protect, and memory parity check. A floating point processor can be optionally added to give the system more computational power.

The *7900 Moving Head Disc* has five million bytes of on-line storage. It can be used to store operating systems, compilers, programs, and program data. The systems' storage can be expanded to 47 million bytes—large enough for the most demanding applications.

The 2748 Paper Tape Reader and 2752 Teletype offer an economical way to access the 2120's capabilities. Other peripherals such as CRT terminals, console/printers, card readers, magnetic tape, line printers, and punches are optional.

The 2120 Disc Operating System was designed to give the small computer user the conveniences of a large system without a high overhead penalty. There are many features which you can choose to make more efficient use of your computer.

Easy System Generation

A user can configure his 2120 system to meet a given I/O configuration. This configuration can be changed by loading memory with another executive from disc or changing the cartridge and loading it.

Mixed Job Stream

In batch mode, multiple job decks can be stacked upon one another, and executed in a load and go environment without manual intervention. FORTRAN, ALGOL, and Assembly Language programs can be intermixed in the same chain of programs. System directives, source code, and data can be integrated into a single job deck.

Disc and Core Memory Hardware Protection

System integrity is assured through hardware memory protection.

System Accounting

The 2120 Disc Operating System can be equipped with a system clock which will tell the operator how long a particular job has taken. The system clock can be also accessed by a program.

Logical I/O Unit Designation

I/O programming is device independent. Programs written in FORTRAN, ALGOL, and Assembly Language specify a logical unit number. Logical unit numbers are assigned to appropriate devices at system generation time, but can be changed by the operator prior to the execution of a program.

Automatic System Disc Management

The system operator can add, change, and delete files from the system disc. All references to files are by name because the 2120 File Management System keeps track of all physical locations. After any file deletion, or edit, the system automatically repacks the disc to eliminate any wasted space.

Extended File Manager

User data files can be written under the command of an extended file manager. Files and record sizes are specified by the user at program execution time. All input/output is buffered to reduce the number of physical disc reads or writes. Records can be accessed on a direct or sequential basis.

Large Disc Capacity

The 2120 Basic System has 5 million bytes of storage and it can expand to 47 million bytes of on-line storage. In addition, data, source statements, and programs can be stored on removable cartridges providing unlimited capacity.

Program Segmentation

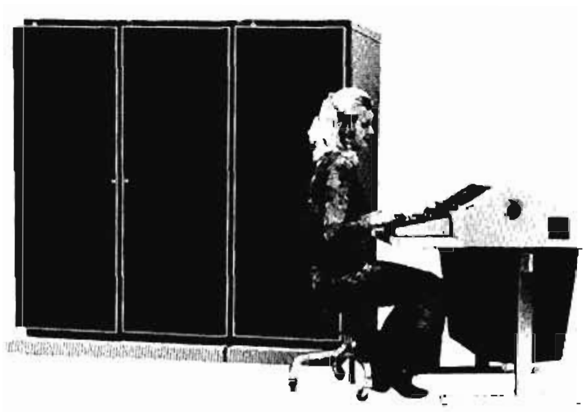
User programs may be structured into a main program with subservient segments. The segments can be stored on the disc and called into memory by the main program when they are needed. The program can use a common area of core for its data.

Utilities

Editing, debugging, and file maintenance utilities are available on the system disc, and they can be called in when needed.

The 2120 is designed to work in a variety of applications. It's a cost-effective system for today and an expandable one for tomorrow.

2000E/F Time-Sharing Systems



The HP 2000E and 2000F Time-Sharing Systems uniquely combine low-cost minicomputer hardware with BASIC language programming to provide interactive problem-solving and data handling for up to 32 users. Both systems use an HP 2100A Computer with floating-point hardware and an HP 7900A cartridge disc. The 2000F adds a second 2100A for a front-end processor. A mix of terminal speeds and types plus access to system peripherals by the user are standard features.

Prices: 2000E <$50,000; 2000F, $105,000.

Operational features:
- 16 (2000E) or 32 (2000F) simultaneous users.
- 10, 15, or 30 cps terminal capability (10 to 240 cps on 2000F).
- 2 (2000E) or 3 (2000F) levels of libraries.
- System backup on removable disc or optional magnetic tape.
- 4.8 to 9.6 Mbytes storage on 2000E; 4.8 to 188 Mbytes on 2000F.
- User/operator communication capability.
- Keyboard, punched tape, or magnetic tape user input/output.
- User programs/files movable to any disc.
- Simple system activation and de-activation procedure.
- System resource utilization and status available to system operator.
- Operator can communicate with all users simultaneously.

Hewlett-Packard extended BASIC:
- All features of standard Dartmouth BASIC.
- Matrix manipulation capability.
- Alphanumeric string capability.
- Random and sequential file access capability.
- Program CHAINing available.*
- Timed input capability.*
- Formatted output capability.*
- Program access to system clock.

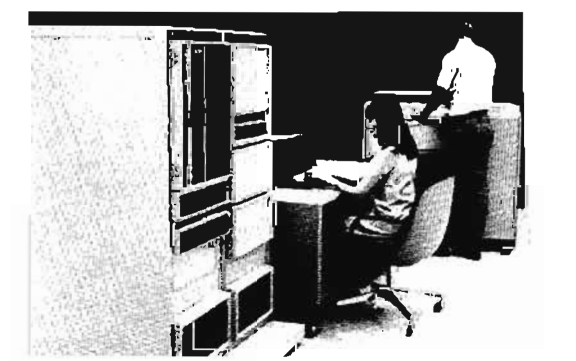
* 2000F only.

HP 3000 Computer System

Hewlett-Packard now offers a disc-based computer system that offers true multiprogramming and multi-lingual capabilities. The HP 3000 Computer System can concurrently handle time-sharing, real-time and batch operations. These capabilities have been previously found only on systems costing three or four times as much.

For terminal-oriented processing, the 3000 can accommodate several users in both multi-lingual time-sharing and data entry/retrieval modes. Or for real-time applications, the fast response to interrupts coupled with sophisticated real-time operating software opens a new level of solutions for process control. For day-to-day processing the system can also handle general-purpose batch activities. The flexibility of the HP 3000 hardware/software lets you tailor the system to your needs.

Operational features:
- Dynamic multi-programming for time-sharing, real-time and general-purpose tasks.
- Stack architecture for ease of compilation and fast execution.
- Dynamic relocatability of user programs.
- Core memory expandable from 32K to 128K bytes.
- Variable length code segmentation for virtual memory operation.
- Concurrent I/O and CPU operations for maximum throughput.
- Built-in protection mechanisms for programs and files.
- 16 and 32-bit fixed-point; 32-bit floating point hardware.
- A complete range of peripherals, including terminals, card readers, card punches, magnetic tape, fixed and removable disc files, line printers and paper tape equipment.



Software:
- Hewlett-Packard's Multiprogramming Executive (MPE) executes many different user and system functions concurrently at the response level appropriate for the job.
- Large machine operating system characteristics at a small machine price.
- Absolute user protection by use of automatic hardware delimiters and software lockwords.
- Spooling for batch input and output.
- Extended ANSI FORTRAN IV, BASIC, and Systems Programming Language (SPL)
- Symbol trace (debug), text editor, scientific routines, statistical analysis routines.
- Hardware diagnostics for on-line or stand-alone checkout.
- Complete facilities for system accounting and monitoring.

Programmable calculators

Variously called a computing calculator, a maxi-calculator, a desk-top computer, or a micro-computer, the programmable calculator is perhaps today's most popular computing device. Combining the convenience of a calculator with the power of a computer, it employs input, memory, processor and display all in a neat, fully self-contained, desk-top package. With the ability to 'memorize' complex mathematical problems involving hundreds, even thousands, of operations and then execute them without human intervention.

What's more, the programmable calculator features extensive data handling capability through a wide range of peripheral equipment. In fact, nearly every type of peripheral device you can find for even the largest computer is available for the programmable calculator: tape drives, plotters, card readers and line printers, to name a few.

In essence, the programmable calculator is a desk-top computer that is specifically defined for problem-solving. To that end, the design emphasis is placed on the interaction between the operator and the machine. So the operator concentrates on solutions instead of programming.

Many calculators have their own step-oriented language, whereby, numbers are first positioned and then operated upon. Recently, 'algebraic' or 'conversational' language calculators came on the scene. Problems are entered just as they are written on paper. Machines with alphanumeric capability permit the user to enter variables in the form of letters, as well as numbers. Nested parentheses can also be used in writing equations.

Most sophisticated of the Hewlett-Packard desktop calculators uses a formal computer language—BASIC. Now a desktop calculator can talk to a computer since its language is compatible. Many programs written for computers in BASIC can also be run on the calculator.

The electronic slide rule

Recently a new breed, the personal, pocket calculator was introduced. The HP-35 is the only scientific pocketable calculator available. It differs from the many four-function (add, subtract, multiply and divide) machines because of its built-in memory and added logarithmic and trigonometric functions. This battery-powered calculator is likened to a fast, electronic slide rule.

Because of their light weight and small size, these minicalculators find a great deal of use in field applications. They are ideal for on-the-spot checking of measurements, such as in surveying. Wherever it is used, in the field or in the office, the HP-35 does away with cumbersome tables, sliderule inaccuracies and bothersome interpolation.

Choose the power needed

Now, the engineer, educator or businessman has a choice of calculators, depending upon the level of sophistication of his problems. The powerful, programmable calculators can be used to solve a wide range of problems that formerly required a computer. With peripherals such as output typewriters and X-Y plotters, input card readers, digitizers and cassette memories, the user can assemble a very powerful computational system. However, where all this power and convenience is not required, the miniature, hand-held units more than suffice.

How do you decide what's best? That's the beauty of dealing with Hewlett-Packard. We build what is clearly the most extensive line of computing alternatives for science and engineering. We build programmable and pocket calculators, general purpose minicomputers, computer systems, terminals and peripherals with the software to match—so it's easy for us to help you find the equipment appropriate for your problems. Call in an Hewlett-Packard field engineer for an honest appraisal of your needs of today and tomorrow.

POCKET CALCULATOR
For science, engineering, and research
HP-35

The HP-35 is a scientific pocket calculator that combines slide rule portability with the precise accuracy and problem-solving power of many desk-top scientific calculators. As easy to use as an adding machine, it goes far beyond the conventional four-function pocket calculators available today. It handles transcendental functions like trigonometry, logarithms, and exponentials (as well as common mathematical functions), with single key strokes, thus eliminating referral to trig or log tables. It displays up to ten significant digits and automatically positions the decimal point throughout its 200 decade range (10^{-99} to 10^{99}). Compared to a slide rule, it provides answers in a fraction of the time with unprecedented accuracy.

Operational stack and memory

The HP-35 provides four registers to serve as an operational stack for intermediate values, plus a fifth register for constants. This feature is found on some computers, but only rarely in a calculator. For both simple and complex problems requiring intermediate values, the stack holds the intermediate results, then brings them back automatically at the appropriate time for further processing. This eliminates scratch notes or re-entry of intermediate values. For review purposes, stack control keys permit any register to be shifted back into the display.

Automatic decimal point positioning

On the HP-35, values can be entered in either floating point or scientific notation. Answers in the range from 10^{-2} to 10^{10} are displayed in floating point with the decimal properly positioned automatically. For values outside this range, answers are displayed in scientific notation with the exponent of 10 displayed at the right.

Battery or ac operation

The HP-35 operates from its own nickel cadium batteries or from ac power. Batteries are recharged automatically when on ac operation. Battery operating time is four hours.

General specifications

Single keystroke functions

Arithmetic: Add, Subtract, Multiply and Divide.

Trigonometric: Sin x, Cos x, Tan x, Arc Sin x, Arc Cos x, Arc Tan x.

Logarithmic: Log_{10} x, Log_e x, and e^x.

Other functions: x^y, $1/x$, $\sqrt{x}$ and data storage and positioning keys.

Power

AC: 115 or 230 V, ±10%, 50 to 60 Hz, 5 watts.

Battery: 500 mW derived from nickel cadmium rechargable battery pack. Meets specifications established by the Radio Technical Commission for Aeronautics, regarding radio frequency interference of devices carried on commerial aircraft.

Dimensions

Length: 5.8 inches (14.7 cm).
Width: 3.2 inches (8.1 cm).
Height: 0.7 to 1.3 inches (1.8 to 3.3 cm).

Weight

Calculator: 9 ounces (255 g). Recharger—5 ounces (142 g).
Shipping weight: approx. 2 lbs (4.4 kg).

Temperature range

0°C to 40°C (32°F to 104°F): operating.
−40°C to 55°C (−40°F to 131°F): storage.

Accessories included

- AC adapter and battery recharger (115/230 V).
- Soft case with belt loop.
- Safety travel case, which holds both calculator and recharger and is compact enough to fit most standard attache cases.
- Self-adhesive owner name tags for the unit and accessories.
- Operating manual.

Price in U.S.A.

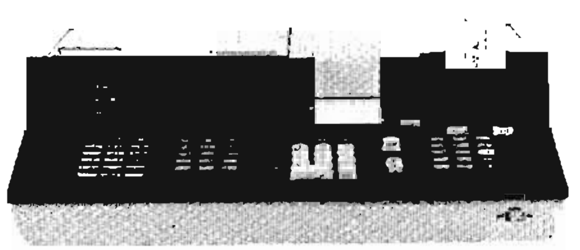
$395, includes accessories shown above, plus taxes.

Optional accessories

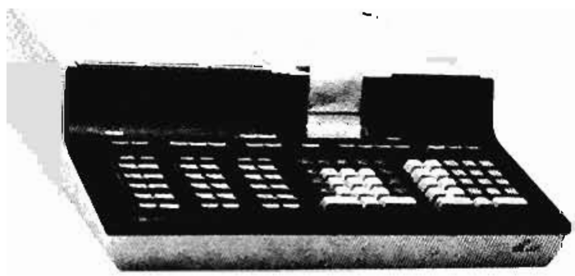
Security cradle: securely locks calculator into a cradle which can be attached to desk or work surface for protection against pilferage. Price, including six-foot stainless steel retaining cable. Price, $24.50.

Battery holder: holds an extra set of batteries for recharging outside the calculator so you always have a fresh set. Price, including batteries, $18.

Field case: rugged felt-lined case protects against dust, weather and bumps. Price, $19.50.



9810A



9820A **NEW**

9830A

Description

From keyboard to memory, and on down the line to peripherals and program packages, modular Series 9800 Calculator Systems can be configured to satisfy an impressive range of disciplinary design needs. In addition, memory can be expanded, peripherals added and keyboard changed at any time without costly modifications. Here are some examples:

Keyboard. You can design your Series 9800 keyboard to give you single-keystroke solutions to a wide range of complex operations. All you need do is insert a plug-in function block in the opening on the top of the calculator and you're ready to go. Each function block has its own built-in memory (ROM)

Memory. If you find that your problems exceed the basic memory of your 9800 Calculator, you can add power at any time merely by inserting memory plug-ins.

Series 9800/Model 10

Perhaps the most versatile member of the programmable family. You'll find Model 10's doing everything from loan analysis in banks and circuit analysis in electronics laboratories to statistical analysis in pathology labs.

In its basic configuration, the Model 10 comes with 500 program steps and 51 data storage registers of memory; a bright, three-register LED display; and a built-in magnetic card reader/recorder for storing and loading programs. In this form, it will easily solve a complete regression analysis . . . or compute a system of 10 simultaneous equations.

For hard copy, you have your choice of two quiet, thermal printer options—numeric or alphanumeric. The alpha option enables you to generate labels, messages, and operating instructions in complete words and sentences right on the printer tape. It's handy for programming, too, since it prints the list of steps identified by symbols (Π, √, etc.) as well as code.

Price: $2475.

Options

Opt. 015, Carrying Handle, $25

Memory Options

- **Opt. 001,** 111 Total Data Registers, $400.
- **Opt. 002,** 1012 Total Program Steps, $500.
- **Opt. 003,** 2036 Total Program Steps, $850.

Keyboard Options and Plug-In Function Blocks

- **11210A,** Mathematics, $485.
- **11212A,** Typewriter, $225.
- **11213A,** User Definable, $485.
- **11214A,** Statistics, $485.
- **11215A,** Plotter, $485.
- **11261A,** Plotter/Printer Alpha Comb., $800.
- **11262A,** Peripheral/Cassette Comb., $625.
- **11264A,** Peripheral, $485.
- **11265A,** Cassette Memory, $225.
- **11266A,** Peripheral/Printer Alpha Comb., $800
- **11267A,** Typewriter/Cassette Comb., $450.

Printing Options

- **Opt. 004,** Printer, $675.
- **11211A,** Alphanumeric Plug-in, $485.

For added power and data handling capability, you can choose from the wide range of custom options and, of course, the Model 10 is compatible with the entire family of Series 9800 peripherals.

Series 9800/Model 20

The conversational calculator, Model 20, is especially suited to scientists and engineers who find themselves faced with lots of on-the-spot programming of complex problems.

Thanks to its natural, algebraic language and conversational alphanumeric display and printer, you can key in the most intricate mathematical problems in the same form you'd write them on paper.

In its basic configuration, the Model 20 comes with display and printer, 173 registers of memory, and a magnetic card reader/recorder for storing and loading programs and data. In this form, Model 20 will easily handle 17 simultaneous equations. Or with an upgrade to 429 registers, 36 simultaneous equations.

For added convenience and power, you can customize the keyboard and expand the memory. And, of course, Model 20

accepts the whole family of Series 9800 peripherals.
Price: $4,975.

Model 20 options

Opt. 015, Carrying $25.
Memory Option
Opt. 001, 429 Total Data Registers, $1,250.
Field Installable Option
11228A, 429 Total Data Registers, $1,290, plus field installation charge.
Keyboard Options and Plug-in Function Blocks
11220A, Peripheral Control I, $485.
11221A, Mathematics, $485.
11222A, User Definable, $485.
11223A, Cassette, ROM, $225.
11224A, Peripheral Control II, $485.

Series 9800/Model 30

Three features really set the Model 30 apart from all other desk-top systems: first is Model 30's language, BASIC plus, a formal computer language that is similar to English in vocabulary and structure. Then there's its built-in Operating System and Firmware Interpreter (implemented by ROM) that handle all executive functions—leaving your main memory completely free for programs and data. And, finally, there's the built-in tape cassette that has features you'd expect only on big computer drives.

In basic configuration, Model 30 comes with 1760 sixteen-bit words of main memory, a 32 character alphanumeric display, built-in tape cassette for program and data storage, and an extensive and powerful keyboard.
Price: Series 9800 Model 30, $5,975.

Additionally, the Model 9866A companion Printer prints 250 lines/minute, 80 character width. **Price:** $2,975.

Model 30 options

Memory Options
Expansion to 4K. Price: $1,475.
Read-Only-Memory: Matrix, $485.
String Variables, $485
Extended I/O, $485.
Plotter, $485.
Terminal I, $485.

Peripherals

Choose the one feature that sets Hewlett-Packard calculators apart from all the rest and that one would be interfacing capability.

Not only can you build an exciting system that will input, store, and output data in a variety of formats, but you can use it as the heart of an automatic test system as well.

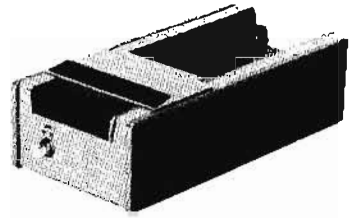
Input Peripherals

Perhaps the most tedious and mistake-prone part of the computing process is the input routine. It need not be. In most laboratories, and in many businesses, data is originally prepared by a machine . . . computers, test instruments, ABS, or teletypes. With the 9800, you can choose the appropriate input peripheral to feed this data to your calculator automatically.

The Model 9860A Card Reader optically reads cards (marked with a soft lead pencil) allowing many users to record programs or data off-line, and then lets them enter their documents in batch. That adds up to calculator machine time saved to do the actual execution of problems.

The Model 9863A Tape Reader reads data and programming instructions into your 9800 Calculator from ASCII/ISO coded punched paper tape at 20 characters per second. If you're getting data from test instruments, machine tools, or computer terminals, the 9863A will eliminate the need to manually re-enter data through your calculator keyboard.

The Model 2748B High Speed Tape Reader optically reads punched paper tape at 300 characters per second. It's ideally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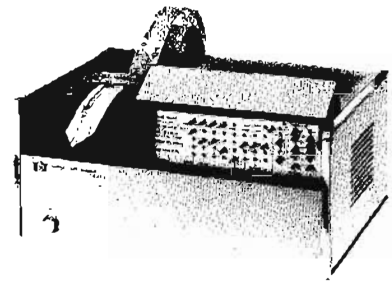
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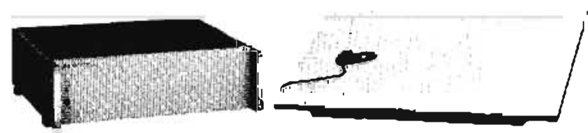
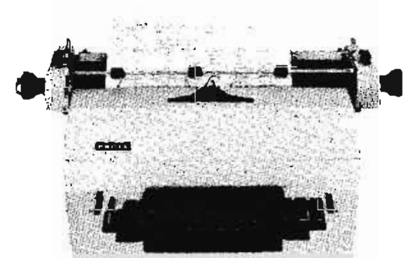

9864A


9865A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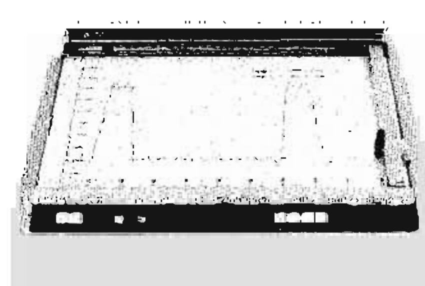
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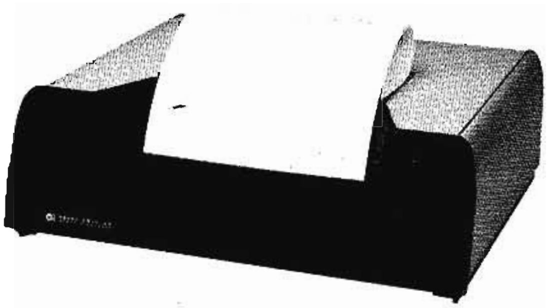


9866A

suited to operations where the work load and volume are extreme.

The Model 9864A Digitizer automatically converts graphic material into digital data and then enters it into your 9800 Calculator for analysis.

It gives you a handy means for analyzing photographs, strip chart recordings, maps, diagrams, cut-and-fill profiles . . . just to name a few. Your imagination's the only limit to the application of this versatile device.

Storage Peripherals

The Model 9865A Tape Cassette provides you not only with a convenient, reliable means of storing and retrieving your data, but for managing your calculator software.

This compact peripheral has performance characteristics that are unprecedented in the computing-calculator field. Its exclusive, precision dual-motor drive, for example, eliminates the problems of tape snarling and tape surge inherent in the more traditional capstan drive systems. Here's why. First of all, any data recorded on one Hewlett-Packard Cassette Drive can be read on any other Hewlett-Packard Cassette Drive. Second and more importantly, there's no fear that the drive will destroy your irreplaceable data tapes.

In terms of operating characteristics, the 9865A has many features that are not usually available on large computer drives. Again, high speed, bidirectional search lets you find any file on the tape . . . from any starting point . . . without rewinding. Furthermore, you don't need two drives for file updating because with the 9865A, you can recall your data, modify it and replace it without disturbing the other information on your tape.

Putting its power in perspective, the 9865A has a minimum capacity of six thousand registers; or 24,000 words for the Model 20 and 30; or 48,000 program steps with the Model 10.

Output Peripherals

With the addition of the appropriate Series 9800 Peripheral, your 9800 Calculator will not only give you answers, but will put those answers into the form required by your operation.

The Model 9861A Typewriter is ideally suited for producing finished reports such as completely documented and formatted problem solutions, business and legal forms, or letters.

With the appropriate peripheral control ROM, your 9800 Calculator automatically controls all typewriter functions including: upper and lower case letters, punctuation, ribbon color, tab setting and clearing, and vertical spacing.

The Model 9862A X-Y Plotter can both draw and write. Histograms, pie-charts, linear, log-log, and polar plots, plus circuit diagrams are just some of the things it can do. The 9862A operates in all four quadrants. Under the control of a Peripheral Control Function Block, the X-Y Plotter can automatically scale your data, generate words as well as numbers and set up both axes complete with labels and tic marks—all in your designated units.

The Model 9866A Thermal Printer gives you big computer printing performance at a small calculator price. This alphanumeric, page-width printer has three features you'll really appreciate. First of all, it's quiet. Perfect for the thinking environment. Second, it can produce full formatted output . . . so it'll set up data tables, draw simple plots, and place text in the format you desire.

Finally, there's its speed. At 250 lines per minute, the 9866A Printer matches the performance of computer line printers costing many dollars more.

The Model 2895B Tape Punch lets you easily add the convenience of a high speed tape output to your Hewlett-Packard system. Combining reliability and compactness in one package, it punches tapes at 75 characters per second, permitting greatly improved system throughput rates.

Additional Options

The Model 9868A I/O Expander allows you to plug up to 13 peripherals and/or test instruments into your Series 9800 Calculator. Although the Expander was specifically designed for use with Series 9800 peripherals and instrumentation interface devices, it has sufficient power reserve to handle many specialty interfaces as well. Data transfer rates and calculator power requirements are unaffected by the I/O Expander.

The Model 11202A TTL I/O Interface Card offers you industry standard TTL levels for input, output, or control lines permitting your 9800 Calculator to handle data in a variety of formats: ASCII, ISO, BCD or ECMA.

The 11202A is analogous to an eight-bit computer duplex card with the distinction that buffer storage is provided for only one direction at a time.

Finally, the Model 11203A BCD Input Interface Card provides the 9800 instruments with an interface to a variety of instruments having parallel binary coded decimal outputs. Direct interfaces are possible to a large number of Hewlett-Packard digital voltmeters, frequency counters, and other instruments.

When used with the 11264A Peripheral Control ROM, the 11203A BCD Input Card has capacity for up to nine digits of data, with function, range, sign, and overload condition.

Prices

(Option number corresponding to calculator with which peripheral is to be used must be specified when ordering.)

Opt. 010 specifies Model 10; **Opt. 020** specifies Model 20; and **Opt. 030** specifies Model 30, e.g. **9860A Opt. 20** for a Mark-Sense Card Reader for Model 20.

9860A Mark-Sense Card Reader, $850.

9861A Typewriter Output, $2250.

9862A Plotter, $2675.

9863A Paper Tape Reader, $1470.

9864A Digitizer, $5900.

9865A Tape Cassette, $1750.

9866A Thermal Printer, $2975.

9868A I/O Expander, $975.

11202A General I/O Interface, $200.

11203A BCD Interface, $300.

2748B High Speed Tape Reader, $1500.

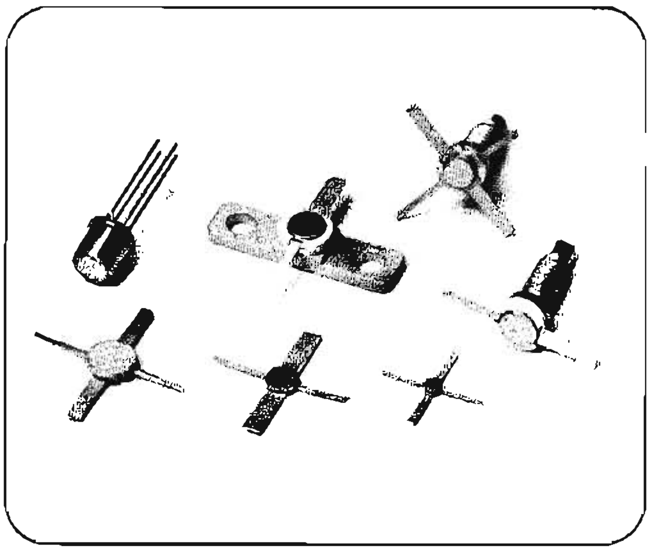
2895B Tape Punch, $2400.

SOLID STATE COMPONENTS & CIRCUITS

Transistors, diodes, hybrid thin film circuits, Solid state displays and optoelectronics

Low cost components, now available from Hewlett-Packard, offer exceptional performance in consumer, industrial, and other OEM equipment. With sophisticated semiconductor processing equipment, and the industry's most extensive hybrid thin-film microcircuit manufacturing facilities, Hewlett-Packard applies newly developed technologies to component manufacturing, offering high performance diodes, transistors, and complete circuits—and also solid state numeric and alphanumeric readouts plus LEDs and other optoelectronic devices—in quantity at economically attractive prices.

Transistors



For RF and microwave amplifiers and oscillators, Hewlett-Packard sets the price and performance standards of the transistor industry. For example, consider this: an NPN silicon transistor with typical f_{max} of 12 GHz at $19 (in stripline package). This transistor (35820 series) puts out 100 mW at 4 GHz with gain typically 7.5 dB, achieved by improved processes that didn't call for reduction in geometeries, hence no compromise in power. Then there is the 35870 series: noise figure guaranteed <2.3 dB at 2 GHz and <3.3 dB at 4 GHz. Or consider the $19 HP 11: it generates over 600 mW at 2 GHz with 8 dB gain using a new design geometry that equalizes power distribution.

Hewlett-Packard transistors fill all requirements for multistage VHF-UHF amplifiers: low-noise input stage, high-gain intermediate stages, and power output stage. Complete data sheet characterization and excellent processing uniformity make it possible to design your circuit by calculation instead of by trial-and-error.

Hewlett-Packard transistors are supplied in chip form, or in several stripline packages in either common-base or common-emitter configurations. The chips have unique moly-gold contact pads that don't deteriorate under high bonding temperatures, improving yields of thin-film hybrid microcircuits.

Look to Hewlett-Packard for further advancements in microwave transistor performance and pricing.

Diodes

Four types of high technology silicon diodes are offered:

Schottky barrier (hot carrier) diodes are unexcelled for fast digital switches, clippers, clamps, samplers, RF and Microwave mixers and detectors both high and low level. Fast recovery, less than 100 ps; turn-on voltage as low as .340 mV at 1 mA; and breakdown levels as high as 70 V give sub-nanosecond switching, high rectification efficiency and low noise. High volume production and extremely low pricing make the diodes ideal for consumer and industrial applications. Excellent diode-to-diode uniformity simplifies applications requiring closely matched diodes.

PIN diodes are advantageous as current-controlled resistors for RF and microwave switching, leveling, electrically-controlled attenuation, and AGC circuits. Long carrier lifetime in some types gives low distortion at signal frequencies as low as 1 MHz; short carrier lifetime in others permits fast RF switching (<5 ns).

Step recovery diodes are ideal for harmonic multipliers and fast-rise pulse generators. Abrupt termination of reverse recovery current can, depending on type, generate voltage steps up to tens of volts with transistion times appreciably shorter than 1 ns. Frequency multiplication from X2 to as high as X100 can produce useful harmonics to 18 GHz.

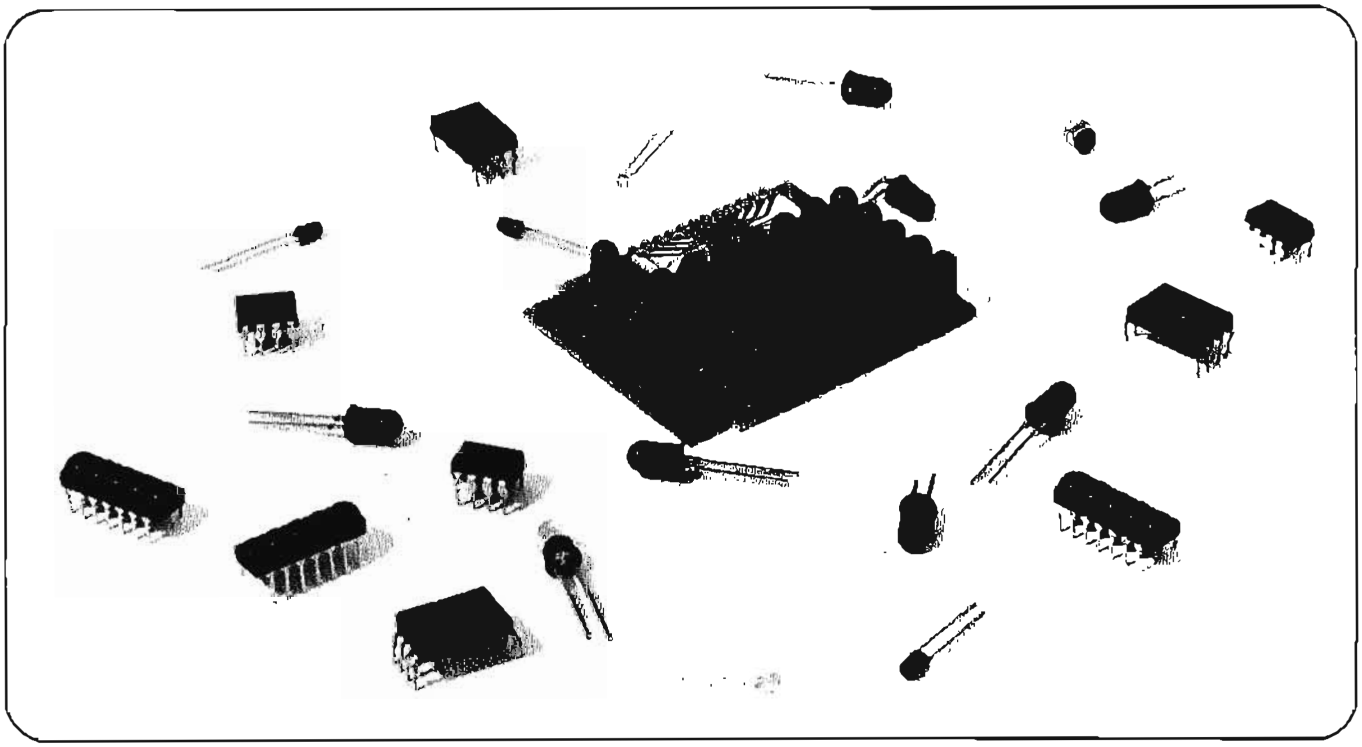
IMPATT diodes are state-of-the-art devices for generating microwave power—as much as 1 W at 14 GHz with 7% efficiency from a single diode. One IMPATT plus a resonator plus a dc power supply equals one simple, inexpensive, solid-state microwave source.

These diodes are available in traditional glass packages, and in special packages for waveguide, coaxial, and stripline mounting. Also available: chips and beam lead packages for hybrid IC mounting.

Hybrid Thin-Film Circuits

Combining Hewlett-Packard transistors and diodes with thin-film circuits has resulted in components ideally suited to the telecommunications field, with performance/price capabilities far beyond that thought possible just a few years ago. The hybrid thin-film technology couples Hewlett-Packard's experience with passive microwave components design and exotic semiconductor devices to form products such as the recently developed 12 GHz receiver front end, all on a single 5″ x 5″ ground plane. A Gunn oscillator, 2 GHz IF amplifiers and a unique packaging configuration give the receiver top performance with high reliability and low cost. S-band repeaters and X-band transmitter power amplifiers for use in common carrier and data communications systems have also been developed offering the same advantages.

Producing a greater quantity of RF and microwave hybrid thin film circuits than any other manufacturer, Hewlett-Packard is well equipped to supply modules in large quantities for reliable and economic OEM systems.



Solid State Displays and Optoelectronics

Hewlett-Packard offers a complete line of GaAsP discrete light emitting diodes (LEDs) and numeric and alphanumeric displays. These components provide solid state reliability to visible data transmission. As status indicators and solid state displays, these compact light emitting diodes are electrically compatible with monolithic integrated circuits (typically 10 mA at 1.5 V), with a useful life greater than 100,000 hours. The visible emitters generate a brilliant red color (655 nm) at levels in the range of 100-200 fL.

Low cost numeric displays, packaged single or clustered, with or without on-board electronics, are available in character heights from 1/9" to 1½". In addition, alphanumeric and hexadecimal displays are available in single or multi-digit packaging for a variety of applications. Small character displays have been designed for portable instrumentation and calculator applications.

These gallium arsenide phosphide displays are offered in plastic encapsulation or hermetic packages. Designed for low cost and ease of application, these displays are ideal for conventional indicator requirements as well as allowing many new applications in the display of information.

Discrete LED indicator lamps are designed for easy panel mounting with clips or direct PC board application. Both plastic and hermetic packages offer high brightness over a wide viewing angle with low power requirements. Hewlett-Packard offers a wide selection of lead, lens, brightness, and package combinations.

Hewlett-Packard offers two new high speed **Optically Coupled Isolators** designed for analog and digital applications. These devices operate up to 20 M bits with an isolation greater than 2500 volts. Ultra-high speed is achieved using an advanced photo integrated-circuit construction. Both devices are available in standard 8-Pin DIP plastic packages.

Hewlett-Packard **PIN photodiodes** are excellent light detectors with an exceptionally fast response of 1 ns, wide spectral response from near infrared to ultra-violet, and wide range linearity (constant efficiency over 6 decades of amplitude). With dark current as low as 150 pA at 10 V, these detectors are especially well-suited for operation at low light levels.

WRITE FOR MORE INFORMATION

Hewlett-Packard component capabilities are described in catalogs and data sheets available for the asking.

**Diode and Transistor Catalog*

Contains key parameters for our line of microwave transistors, Schottky, PIN, Step Recovery and IMPATT diodes, including chips and devices for hybrid integrated circuits.

**Optoelectronics Catalog*

Contains key parameters for our broad line of LED readouts, LED lamps, new Optically Coupled Isolators and Detectors.

**Microwave Conversion/Control Components Data Sheets*

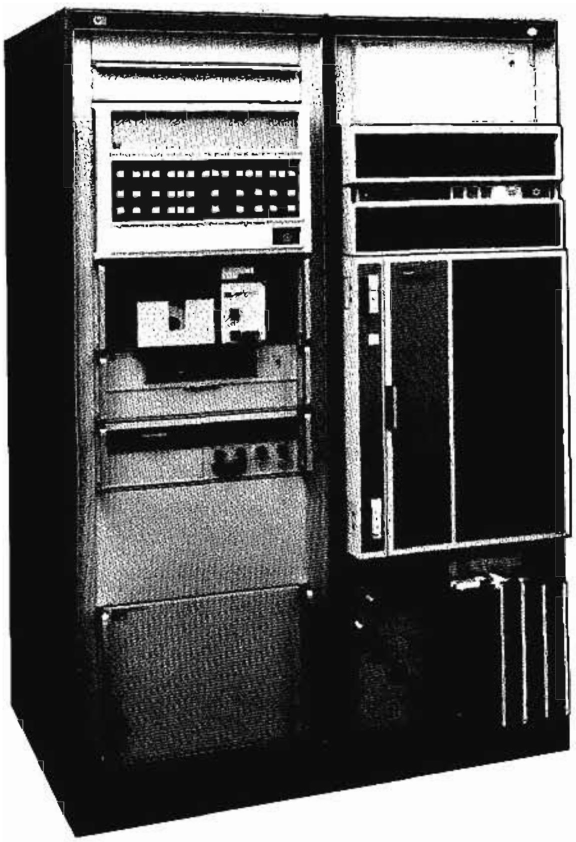
Data sheets contain complete specifications on modulation, SRD modules, limiters, detectors, switches and attenuators.

These catalogs, application notes and other literature, including prices, are as near as your phone. Call any Hewlett-Packard Sales Office.

CABINETS

Rugged, durable, and ready-to-use

29400 Series



Typical instrumentation racking in a 29400 series cabinet

The Hewlett-Packard 29400 series of rack cabinets offer a wide choice of exceptionally rugged, yet light-weight enclosures. Choices including one-, two-, and three-bay cabinets with 35, 56, and 70 inch vertical panel openings (35 inch panel opening available on one-bay cabinet only). The enclosures accept instruments with a standard front panel width of 19 inches and a depth of up to 27 inches. Except for the 35 inch model, cabinets are equipped with eyebolts and casters for ease of handling. An optional extended base can be included with the cabinet and is recommended for enclosures to be equipped with computers, tape units, or any other heavy instrument that swings or slides outward for servicing. Fixed instrument support rails are supplied as follows: 4 pairs per 35 inch bay; 5 pairs per 56 inch bay; 6 pairs per 70 inch bay.

Cabinets are also available fully wired in accordance with IEC specifications. Included with all electrical options is one fan per bay to maintain the temperature rise to less than 15°C over ambient temperature where internal power consumption per bay does not exceed 2000 watts (500 watts for 35 inch cabinets). One outlet strip per bay is provided with all electrical options.

A number of accessories are also available and can be included with the cabinet or installed at a later date. These accessories include transparent or solid front doors, storage drawers, writing surfaces, and blank front panels.

Cabinets and cabinet accessories which have an A/B suffix after the model number are available in a choice of two color schemes. Suffix "A" models (29403A, 12694A, etc.) are finished in textured blue-grey with light grey panels and suffix "B" models (29403B, 12694B, etc.) are finished in moss-grey with mint grey panels. Those accessories listed with the suffix "B" only, are compatible with either the 29400A or 29400B series cabinets.

Customers unable to find a standard cabinet to meet their particular physical or electrical needs may have cabinets built on a special order basis.

Cabinet specifications

Model	No. of Bays	Overall Width ①	Panel Height ①	Overall ① Height ③	Net Weight ②
29401 A/B	1	21 (533)	35 (889)	43.25 (1099)	115 (52.2)
29402 A/B	1	21 (533)	56 (1422)	64.25 (1632)	148 (67.1)
29403 A/B	1	21 (533)	70 (1778)	78.25 (1988)	168 (76.2)
29404 A/B	2	42 (1067)	56 (1422)	64.25 (1632)	271 (122.9)
29405 A/B	2	42 (1067)	70 (1778)	78.25 (1988)	310 (140.6)
29406 A/B	3	63 (1600)	56 (1422)	64.25 (1632)	401 (181.9)
29407 A/B	3	63 (1600)	70 (1778)	78.25 (1988)	461 (209.1)

Notes: ① Dimensions in inches and (millimeters) ② Dimensions in pounds and (kilograms) ③ Overall height does not include eyebolts

Options

Option 001 Extended Base: This option provides a 7¾ inch extension of cabinet base to provide extra stability.

Electrical options

Option Number	Primary Power Input 50 - 60 Hz	Internal Power	Remarks
010	115 Vac	115 Vac	
011	230 Vac (USA) Split Phase	115 Vac	Available only with 29404 A/B & 29405 A/B
012	230 Vac (Europe)	230 Vac	
013	115/208 Vac 3 phase	115 Vac	Available only with 29406 A/B 29407 A/B

Electrical options are supplied with one power strip per bay as follows:
6 outlets per strip with 35" cabinets rated at 10 Amps per bay at 115 Vac (5 Amps at 230 Vac).
9 outlets per strip with 56" cabinets rated at 20 Amps per bay at 115 Vac (10 Amps at 230 Vac).
11 outlets per strip with 70" cabinets rated at 20 Amps per bay at 115 Vac (10 Amps at 230 Vac).

Option 030 Power Strip: This option provides electrical outlets for instruments mounted in the cabinet. Strips can be used with above electrical options to increase number of outlets. (Load capacity of cabinet is not increased by additional outlets.)

Rack cabinet prices

Model	29401 A/B	29402 A/B	29403 A/B	29404 A/B	29405 A/B	29406 A/B	29407 A/B
BASIC PRICE:	$575	$650	$700	$1200	$1375	$1600	$1800
Options:							
001	$50	$50	$50	$80	$80	$120	$120
010	250	350	350	450	475	700	700
011	N/A	N/A	N/A	450	475	N/A	N/A
012	250	350	350	450	475	700	700
013	N/A	N/A	N/A	N/A	N/A	700	700
030	40	45	50	45	50	45	50

Cabinet accessories

Front doors: cabinet front doors, listed in the table below, provide 2.56 inches (65 mm) from front of rack mounted instrument to inside of door to allow for knobs and other protrusions; this adds 2 inches (50,8 mm) to cabinet depth. All doors include a key-lock. Order by Accessory No. Specify right or left opening.

Cabinet front doors

Transparent (Grey Tint) Panel			
Height In (mm)	Accessory No.	Net Weight Lb (kg)	Price $
12.25 (311)	12696B	6 (2,7)	180
31.5 (800)	12693B	12 (5,4)	190
56 (1422)	12677B	18.5 (8,2)	200
70 (1778)	12687B	22.5 (10)	210

Blue Grey or Mint Grey Panel

12.25 (311)	12697A/B	5.5 (2,4)	160
31.5 (800)	12694A/B	10 (4,5)	170
56 (1422)	12678A/B	16 (7,2)	180
70 (1778)	12688A/B	19.5 (8,8)	190

Wood Grained Panel

12.25 (311)	12698B	6 (2,7)	160
31.5 (800)	12695B	12 (5,4)	170
56 (1422)	12686B	18.5 (8,2)	180
70 (1778)	12689B	22.5 (10)	190

Front door option: (specify front door Accessory No. plus Option No).

Option 003: extra-deep door for 56- or 70-inch cabinet. Allows 5.56 inches (141 mm) from instrument front panel to inside of door. Adds 5 inches (127 mm) to cabinet depth.

Price: add $20.

Equipment slides: 150 lbs (68 kg) load capacity. Order by Accessory No.

Accessory No. 12692B: slide for mounting non-Hewlett-Packard instruments. Price: $60.

Accessory No. 12692B-002: brackets for mounting 3.5 inch (88,9 mm) high Hewlett-Packard instruments. Price: $85.

Accessory No. 12692B-003: brackets for mounting Hewlett-Packard instruments over 3.5 inches (88,9 mm) high with handle recess. Price: $85.

Storage drawers: 75 lbs (34 kg) load capacity; installed at bottom of cabinet if no other location is specified. Order by Accessory No.

Height		Depth		Accessory No.	Price
In.	mm	In.	mm		
3.5	89	16	406	12672A/B	$90
5.25	133	16	406	12673A/B	

Instrument support rails: one pair with attaching hardware. Order Accessory No. 12679B. Price: $10.

Writing surfaces: topped with white Formica. Fixed shelves are removed for shipping. Slideout shelf is installed if ordered with cabinet. Order by Accessory No.

Type of shelf	Usable area In. (mm)	Panel height	Accessory No.	Price
1-Bay Slide-out	16 x 16.5 (406 x 419)	3.5 (89)	12674A/B	$140
1-Bay Fixed	15 x 20 (381 x 508)	1.75 (44)	12675B	$100
2-Bay Fixed	15 x 41 (381 x 1041)	1.75 (44)	12676B	$150

Blank panels: Hewlett-Packard grey or mint grey with attaching screws. Order by Accessory No.

Height In. (mm)	Accessory No.	Price	Height In. (mm)	Accessory No.	Price
1.75 (115)	12680A/B	$10	7 (178)	12683A/B	$10
3.5 (89)	12681A/B		8.75 (222)	12684A/B	
5.25 (133)	12682A/B		10.5 (267)	12685A/B	

CABINETS, ENCLOSURES & ACCESSORIES

Modular enclosure systems

The Hewlett-Packard modular enclosure system provides a complete solution to instrument packaging and mounting problems. The system is in accord with EIA standard rack and panel dimensions, yet each enclosure is equally well suited to bench or field use.

Two types of instruments

Basically, instruments enclosed in the modular system fall into two classes: (1) instruments which require full EIA rack width. These instruments mount directly in racks by means of brackets and filler strips included with the instruments. Feet and tilt stand are provided for bench use. Instruments can be stacked for maximum utilization of available space. (2) instruments which require only one-third or one-half the full module width. Adapter frames are available for mounting in standard EIA racks. Combining cases and rack adapter frames use blank panels to fill areas not used by instruments and provide convenient storage of leads, cords, etc. Model 1052A Combining Case accepts cooling kits to maintain proper ambient temperature.

Specifications

Combining cases

11046A accepts third-module instruments.

Dimensions: 19¼" wide, 8⅜" high, 13¼" deep (489 x 213 x 367 mm), $150.

1051A accepts third- or half-module instruments up to 11¼" (286 mm) deep.

Dimensions: 16¾" wide, 7¼" high, 13¼" deep (425 x 185 x 337 mm); hardware furnished for conversion to rack mount 19" wide, 6-31/32" high, 11¼" deep behind panel (483 x 177 x 286 mm).

Weight: net 11 lbs (5 kg); shipping 15 lbs (6,8 kg).

Price: HP 1051A, $135.

1052A accepts third- or half-module instruments up to 16⅜" (416 mm) deep.

Dimensions: 16¾" wide, 7¼" high, 18⅜" deep (425 x 185 x 467 mm); hardware furnished for conversion to rack mount 19" wide, 6-31/32" high, 16⅜" deep behind panel (483 x 177 x 416 mm).

Weight: net 13 lbs (5,9 kg); shipping 18 lbs (8 kg).

Price: HP 1052A, $150.

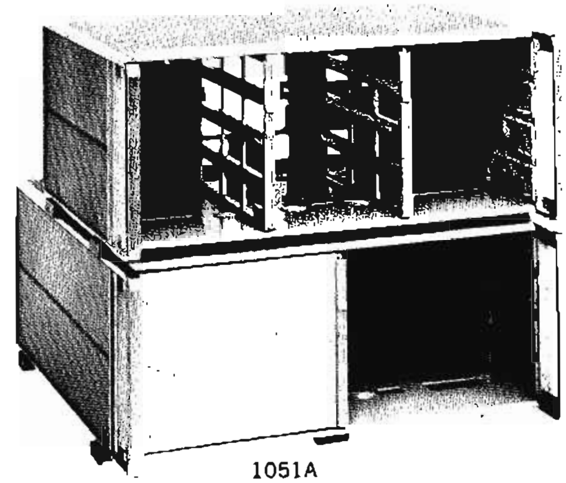
Rack adapter frame

Blue/grey

5060-0797 Adapter rack mounts third- and/or half-module instruments up to 6-3/32" high (155 mm), $25.

5060-0808 Adapter rack mounts third- and/or half-module instruments up to 3" high (75 mm), $25.

Note: Mint Grey is new Hewlett-Packard light grey color. Blue Grey matches color of earlier instruments (Color change began in late 1971.)



1051A
1052A

Mint grey

5060-8762 Adapter rack mounts third- and/or half-module instruments up to 6-3/32" high (155 mm), $25.

5060-8764 Adapter rack mounts third- and/or half-module instruments up to 3" high (75 mm), $25.

Joining brackets

5060-0215 Joining Bracket Kit for semi-permanently joining any two full-module instruments 11¼" (286 mm) deep behind the front panel, $20.

5060-0216 Joining Bracket Kit for semi-permanently joining any two full-module instruments 16⅜" (416 mm) deep behind the front panel, $25.

Control panel covers

These covers quickly convert full-width cabinets to easily carried portable units.

Control panel covers

PART NO.		EIA Panel Height		
Blue Grey	Mint Grey	(in.)	(mm)	Price
5060-0826	5060-8766	3-15/32	88	$22.50
5060-0827	5060-8767	5-7/32	133	25.00
5060-0828*	5060-8768*	6-31/32	177	27.50
5060-0829	5060-8769	8-23/32	222	28.50
5060-0830	5060-8770	10-15/32	266	30.00
5060-0831	5060-8771	12-7/32	310	32.50

* Also fits HP 1051A and 1052A.

Instrument cases

11075A accepts third-module instrument 6½" high 8" deep.
Weight: net 3 lbs (1,4 kg); shipping 5 lbs (2,3 kg).
Price: HP 11075A, $60.

11076A accepts third-module instrument 6½" high, 11" deep.
Weight: net 3 lbs (1,4 kg); shipping 6 lbs (2,7 kg).
Price: HP 11076A, $60.

Field cases

The Hewlett-Packard field cases are rugged protective outer shells for use when instruments must be frequently transported and used away from laboratory conditions. They are molded of strong fiberglass-reinforced plastic and sealed tightly, making them rainproof under the test conditions of MIL-STD-108. Cases meeting MIL-C-4510 are available. Carrying handles fold flat when not in use. Two basic case styles are available: transit and operating. Cases are available to accommodate nearly any instrument and combination of accessories. Special size cases can also be ordered. A technical data sheet is available.

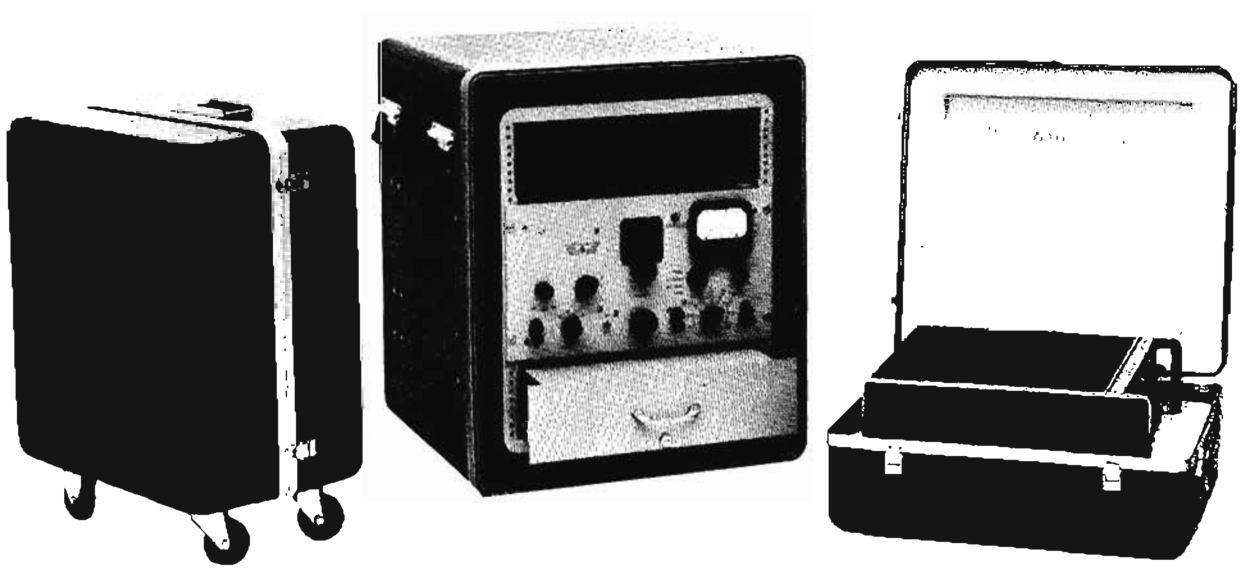
Transit cases

Transit cases are typically provided with foam cushions custom-formed to fit the standard Hewlett-Packard modular cabinets. This arrangement provides maximum protection against damage from handling, dropping, or crushing. Prices: $70-$220.*

Operating cases

Operating cases are equipped internally with shock-mounted frames that accept combinations of any standard 19-inch rack-mounting instruments up to the maximum height of the frames. This arrangement offers the convenience of operation without removing the instrument from its carrying case. At the same time, environmental protection is afforded. Drawers and casters are available. Prices: $460-$685.*

* Quantity discounts available.



ACCESSORIES
Cable assemblies
For general purpose use

Instrument accessories

Cables

10501A Cable Assembly $8

44″ of 50Ω coaxial cable terminated on one end only with UG-88C/U BNC male connector.

10502A Cable Assembly $12

9″ of 50Ω coaxial cable terminated on both ends with UG-88C/U BNC male connectors.

11086A Cable Assembly $12

24″ of 50Ω coaxial cable terminated on both ends with UG-88C/U BNC male connectors.

10503A Cable Assembly $13

48″ of 50Ω coaxial cable terminated on both ends with UG-88C/U BNC male connectors.

10519A Cable Assembly $13

72″ of 50Ω coaxial cable terminated on both ends with UG-88C/U BNC male connectors.

11000A Cable Assembly $13

Dual banana plugs terminate a section of 50Ω cable, 44″ over-all; plugs for binding posts spaced ¾″.

11001A Cable Assembly $13

Identical with 11000A except dual banana plug on one end and UG-88C/U BNC male on the other.

11035A Cable Assembly $12

12″ of 50Ω coaxial cable terminated on one end with a dual banana plug and on the other end with a UG-88C/U BNC male connector.

11002A Test Leads $10

Dual banana plug to alligator clips, 60″ long.

11003A Test Leads $10

Dual banana plug to probe and alligator clip, 60″ long.

11143A Cable Assembly $25

44″ of balanced shielded cable, BNC to clip lead.

11500A Cable Assembly $20

72″ of 50Ω coaxial cable terminated on both ends with UG-21D/U Type N male connectors.

11501A Cable Assembly $20

72″ of 50Ω coaxial cable terminated with UG-21D/U Type N male and UG-23D/U Type N female connectors.