



96000

COMPUTER SYSTEMS

For data acquisition and control . . .



HP Computer Museum
www.hpmuseum.net

For research and education purposes only.



Hewlett-Packard 9600 . . .

. . . identifies a new series of sensor-based data acquisition and control systems -- systems designed to take, process, and control physical measurements in Research and Development, Manufacturing, and Production applications. By using these systems to speed up the acquisition, processing, and output of data, you can increase the productivity and profitability of your operation. More and more research lab managers, manufacturing managers, and production managers are realizing this. They have seen that the cost effectiveness of their operation is increasingly dependent upon the speed and accuracy with which essential data is acquired, processed, and provided in readily interpretable form to those responsible for acting upon it. Hewlett-Packard 9600 Systems are uniquely qualified by our more than 16 years' experience in building automatic measuring systems and more than 30 years of contribution to the fields of measurement and instrumentation. For this reason, and others noted in this section, we believe you will want to seriously consider HP 9600 data acquisition and control systems for your applications.

HP 9600 Systems . . .

- Control production tests or lab experiments through digital and analog interfaces.
- Coordinate stimulus and measurement actions of the various instruments used for data acquisition.
- Acquire and convert analog data from strain gages, pressure transducers, and other physical sensors to digital form.
- Correct the data for non-linearity of the sensors and for offsets and convert the data to meaningful scientific or engineering units.
- Calculate results (efficiencies, flow rates, heating trends, statistical distributions, etc.)
- Check results against limits.
- Log or display results.
- Free the operator for more important supervisory or creative, experiment-design work.
- Take information that would otherwise be difficult to obtain.



Because of our experience, we've already solved problems years ago that other suppliers, less experienced in analog measurement techniques, are only starting to deal with — problems like making accurate measurements of millivolt-level signals from strain gages, thermocouples, and other physical sensors, in the presence of noise orders of magnitude greater. Thus, we can apply proven Hewlett-Packard solutions to your data acquisition and control applications more reliably and effectively than any other supplier.

We make virtually all of the analog and digital input/output instruments and interfaces used in our systems, as well as the new HP 2100A Computer which serves as the system controller. Moreover, we assume sole source responsibility for all subsystems, interfaces, and peripherals purchased with your system. This enables us to optimize the overall performance, reliability, and serviceability of your system. The instrumentation, interfaces, and peripherals available in 9600 Systems are described in pages 8 through 25.

Hewlett-Packard 9600 series Systems mobilize data taking, processing, control, and data logging capabilities into one powerful, high-speed facility. The benefits of these systems are greatest with respect to applications in which experiments, manufacturing or production tests, calculations, and data logging are now performed manually, because the computer-controlled 9600 series System is far faster than any person, does not tire, and is not subject to human error. With respect to non-computer data acquisition systems, a 9600 System is faster, far more flexible, and offers the advantage of processing of acquired data immediately into usable form. The patience-trying wait for processing of data from records on punched cards, punched tape, or magnetic tape at a central facility is bypassed. Researchers particularly benefit from faster turnaround of data, which cuts the time from completion of an experiment to examination of results to nearly zero, helping to sustain interest and creativity at a high level while a particular line of inquiry is being pursued.

HP 9600 series Data Acquisition and Control System Fit Your Applications. At Hewlett-Packard, *modularity* is far more than just a word. It is the fundamental philosophy on which our 9600 series Systems are based. Modularity means that we can supply a system with all of the elements required to meet your needs today at a cost you can afford today. This same system can be *expanded* at reasonable cost, without system redesign or discarding equipment already purchased.

System memory capacity is plug-in expandable from 8,192 words to 32,768 words, at any time, at your facility. Input/output capacity of the controller is expandable from 14 to 45 channels. All subsystem and peripheral packages are carefully engineered for hardware and software compatibility, so they are readily assembled into a 9600 system that satisfies your exact requirements today, and are easily added to expand your capabilities tomorrow. Additional configuration flexibility is provided by our new computer-to-remote ter-

minal communications capability. This lets you locate remote data acquisition terminals close to physical data sensors. Data from these terminals are transmitted in digital form to a central computer that serves as the controller and data processor of the distributed system. Our program of developing new system facilities, such as this new communications capability, combined with our commitment to modularity, provides your best assurance of continuing use and value from your HP 9600 System.

HP 9600 series Data Acquisition Systems are Reliable and Fully Supported. An important area of concern with any computer system is system availability and up time. Typical customer comment on the reliability and support we provide (on a system purchased in November 1967) is contained in the following quotation from the April 1970 issue of *Control Engineering*, (Justifying Computerized Testing, page 85):

"At the time, purchase of the computer was a unique experience for both Kearsfott and the vendor, Hewlett-Packard. For a few months after the delivery of the first computer, there were maintenance and performance problems while HP was establishing a national computer sales force and support organization. Since that time, maintenance, repair, and vendor software support have been outstanding. The vendor provided software which was virtually error-free, and the computer hardware has been performing for close to two years, 24 hours per day, seven days per week, without shutdown periods of more than four hours because of any malfunction. The computer is amazingly reliable."

That was four years ago, and since then we've delivered hundreds of computer-controlled instrumentation systems. This experience has enabled us to improve further our support to our customers with each system we deliver. As a result, Hewlett-Packard's support organization is well established world-wide, providing a full range of support services. HP support for systems includes regular user training courses, comprehensive system documentation, data centers where users may obtain programming assistance, 59 service offices in the U.S. and 22 in Europe, system warranty, and service agreements. More information on these support services is presented on pages 26 and 27 of this brochure.

HP 9600 series Systems are User-Proven. Since HP introduced its first mini-computer in 1966, HP has built and delivered over 3,000 mini-computers and 700 computer-controlled instrumentation systems. The 9600 series Systems now available are described on the next two pages. The systems we've sold are being used in a wide variety of applications, some of which are briefly summarized on pages 6 and 7. We invite you to become familiar with this information and with the capabilities that computer-controlled HP 9600 series Data Acquisition and Control Systems can bring to your application, which are presented in this brochure.



One of the automatic system assembly areas at Hewlett-Packard.

A Choice of Four Systems

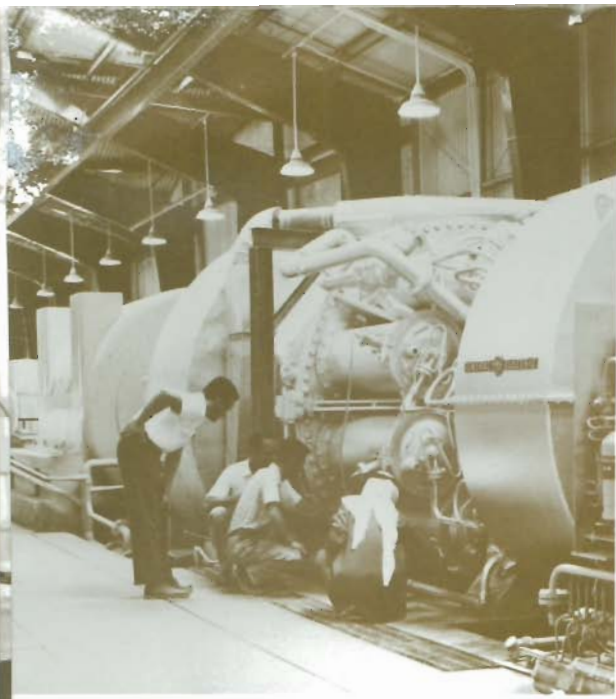
9600 SERIES SYSTEM PHILOSOPHY. Hewlett-Packard 9600 series Systems are designed to help you accomplish your data acquisition and control objectives with a minimum expenditure of time and effort on your part. It is relatively easy, and makes sense for you, the user, to do your own applications programming. On the other hand, it makes little sense for most users to have to write programs providing the general operational framework and utility services required in the system. For this reason, all HP 9600 series Systems are provided as an integrated hardware-software package that is mobilized by its operating system into a solid foundation for solutions to your data acquisition and control applications.

BASIC SYSTEM HARDWARE

Certain basic hardware is included in all 9600 series Systems. An HP 2100A Computer with 8,192-word memory serves as the system controller and data processor. A teleprinter serves as the operator communication terminal of the system. A tape reader speeds punched tape input. All systems are housed in a rugged, prewired cabinet, and the more capable systems include additional hardware. Regardless of the system you choose from the four listed below, the effect of obtaining it as an integrated hardware-software package will be to minimize your programming involvement with the system itself, and to gain you more time for preparation of programs related directly to your applications.

One of the greatest advantages of HP 9600 series Systems is the ease with which they can be upgraded at your facility. A 9600A System can be upgraded to a 9600G System by adding a time base generator and reconfiguring the system with the new combination of software. This is a relatively simple procedure that does not require rewriting of application programs. Similarly, a 9600G System can be upgraded to a 9600E or 9600F System by adding the desired disc memory, increasing controller memory capacity to 16,384 words, and by reconfiguring with the appropriate software. Our "pay as you grow" 9600 series Systems design lets you start with your immediate needs and build to suit new requirements, right up to real-time executive systems and distributed systems.

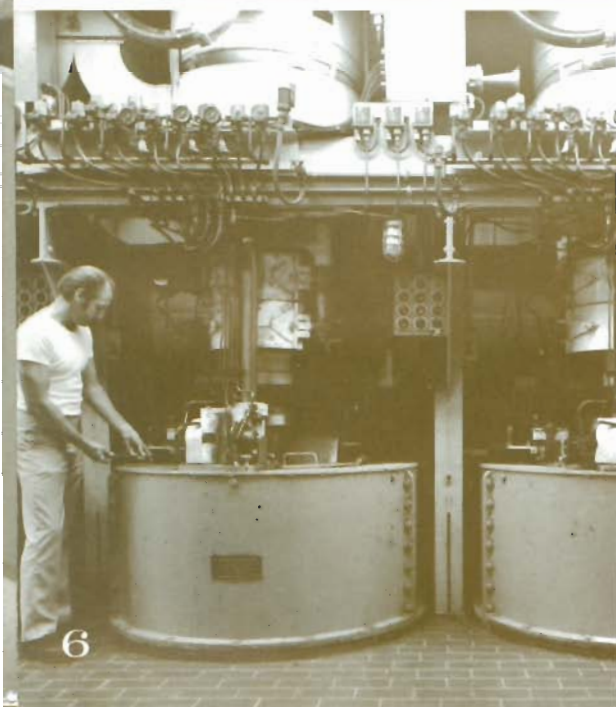
| SYSTEM | DESCRIPTION | PROGRAMMING LANGUAGES | USE AND ADVANTAGES |
|--------|--|---|---|
| 9600A | Basic Control System for I/O supervision and linking user's programs. | HP FORTRAN HP ALGOL HP Assembler | For one-program-at-a-time data acquisition and control applications not needing real-time scheduling. Interrupt processing and output buffering assure efficient use of system facilities. |
| 9600G | Core-based real-time scheduler for one-at-a-time data acquisition assignments. | HP FORTRAN HP ALGOL HP Assembler | For real-time-scheduled data acquisition and control applications not requiring concurrent operation of multiple programs. Operator has direct access to program parameters without recompiling. Interrupt processing and output buffering assure efficient use of system facilities. |
| 9600E | Disc-based Real Time Executive using moving head disc. | HP FORTRAN IV HP FORTRAN HP ALGOL HP Assembler | For real-time concurrent operation of multiple programs, such as used to control and take data from multiple test stations or different experiments in a research lab. Also offers concurrent background operation for compiling programs and for other non-real-time processing. Moving head, interchangeable cartridge disc offers 2.5 million word storage capacity, expandable to 10 million words with additional disc drives. |
| 9600F | Disc-based Real Time Executive using fixed-head-per-track disc. | HP FORTRAN IV HP FORTRAN HP ALGOL HP Assembler | For same uses as 9600E System. Fixed-head-per-track disc provides fastest access to programs on disc and 262,000 word capacity, expandable to 1 million words. |



Gas Turbine Combustor Development is being aided by an HP 9600 series system at the General Electric Company Gas Turbine Operations in Schenectady, New York. Designing successful combustion systems for gas turbines involves a number of factors which are so interrelated that an improvement in one area may be detrimental in another. GE combustion systems are the result of a balanced design concept with particular emphasis on proper ignition and fuel injection, holding internal pressure drops to reasonable limits, maintaining stable combustion with no loss of flame from full fuel flow to a no-load value, proper temperature distribution at the turbine inlet (the hottest part of the gas turbine), and reduction of carbon which can deposit inside the combustors and also show up as smoke in the stack. The system measures temperatures, pressures, and air and fuel flow, providing test data and computed performance immediately after a test is completed. This enables the combustor designers to evaluate parameters and plan and initiate additional tests without waiting for results, which previously had required about four hours to obtain.



Testing Automobile Exhaust Emissions is the assignment of Hewlett-Packard 9600 series systems serving General Motors, Ford, Mercedes-Benz, Volkswagen, Fiat, and Olson Laboratories at assembly plants, proving grounds, testing facilities, and mobile laboratories in North America and Europe. These systems provide programmed instructions to the operator, who drives the car during its test on a dynamometer. The systems automatically calibrate, average, and linearize the digitized analog outputs of the gas analyzer used to detect pollutants. As required by the test, concentration values, in percent and parts per million, are converted to the mass equivalents in grams per mile. With the automatic system, the test time is held to the duration of the test cycle itself, with a test report obtained as soon as the test cycle is completed. Another benefit is that the test system provides a modal breakdown of pollutant emission within the test cycle, enabling the cause of failed tests to be quickly determined. In view of the volume of testing to be performed, computer systems offer the only practical solution in the field of automobile exhaust emission testing.



Controlling the rate of sugar production with an HP 9600 series system at the Redpath Sugar Refinery of the Canada and Dominion Sugar Company in Toronto, Ontario, Canada, is achieving a steady flow of sugar at close to the plant's peak output capacity. Prior to use of the HP system, output varied from 40,000 pounds per hour to the plant's capacity of 80,000 pounds per hour. The HP equipment monitors production stages (such as the affination machines shown at left), makes calculations based on the collected data, and then adjusts timers and controllers to maintain a high sugar output. With the system, over 78,000 pounds of sugar are processed per hour. In addition to increasing the productivity of the plant, the efficiencies achieved through use of the system have allowed the reduction of in-process inventories by decreasing tank sizes.

Additional information on these and other applications of HP computer systems is provided

- AN135-1 Computerized Data Acquisition Aids Final Testing (Dresser)
- AN135-2 High-Volume Production Testing (Raytheon)
- AN135-3 Process Monitoring in Manufacturing (Norton Company)
- AN135-4 Closed-Loop Production Testing (Chandler Evans)
- AN135-5 A Mobile Process Control Laboratory (Shell Development)
- AN135-6 Computer Analysis Aids Battery Testing (TRW Inc.)



9600 Series Systems in Action

At Sea HP 9600 series systems are taking and processing oceanographic research data on location for the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. All system inputs are in digital form and include date and time, gravity, ship's velocity, earth's magnetic field, and water depth. Ambient temperature is also available on an analog strip chart record. These data are related to ship's position in latitude and longitude, and to ship's velocity. (In the photo, a research scientist is lowering a magnetometer probe into the sea for a series of measurements.) The systems allow scientists to better evaluate and interpret data while an investigation is being conducted at sea. Onboard data reduction makes it possible to repeat measurements on location to replace bad data or augment with more information if required. The result is a savings in time and cost because the possibility of unknowingly returning home with faulty data is minimized.

HP 9600 series Computer Systems are helping the Raytheon Company at Lowell, Massachusetts, to maintain a high volume of production-tested modules and subassemblies for military weapon systems. A system typically makes five different measurements for each of ten different combinations of test stimuli, all in 40 to 90 seconds, depending upon module complexity. The first 9600 series system applied to this service proved to be so successful that three additional systems have been installed to handle Raytheon's test needs for various other weapon systems manufactured at the Lowell facility. Systems such as these being used by Raytheon offer the only practical means of achieving high test rates at a reasonable cost per module tested.

An HP 9600 series system on board the aircraft shown taking off from Moffett Field, California, is being used to assist airborne research in many areas of scientific discipline. The research programs assisted by this system and directed by the NASA Goddard Space Flight Center in Greenbelt, Maryland, include studies in aerodynamics, earth resources, meteorology, geophysical observations, and studies of the sun, stars, and planets. Much of the knowledge gained from the research flights is used to develop instrumentation for space vehicles such as the weather satellite, NIMBUS, and the orbiting geophysical observatory, OGO. The system reduces and records the scientific data, providing it to the scientists on board the aircraft in quick-look form to confirm the general validity of the data. In addition to reducing and recording the scientific data for quick-look purposes, the HP system records the aircraft position (from information supplied by the aircraft navigational system) throughout each mission. This provides a very detailed compilation of positional information so that the raw measurements, also being recorded for more thorough processing, can later be ground referenced precisely. The in-flight data reduction provided by the system makes it possible to recognize faulty or incomplete data in time to repeat measurements or make additional measurements as required while the aircraft is still in the area where data is being taken. All HP equipment in this system is standard, including the computer.



the following application notes, which are available from Hewlett-Packard Field Sales Offices.

- AN135-7 Data Acquisition and Analysis at Sea (Woods Hole)
- AN135-8 Minicomputer System Aids Busy Psychology Lab (UCLA)
- AN135-9 In-Flight Data Analysis Improves Airborne Research (NASA-Goddard)
- AN135-10 Computer System Speeds Gas Turbine Combustor Testing (General Electric)
- AN135-11 Stable Measurements on the High Seas (Scripps)
- AN135-14 Computerized Process Control Improves Sugar Refinery Production (Redpath)

System Concept

Hewlett-Packard 9600 series Systems for Data Acquisition and Control of external equipment or processes are assembled on the foundation of the base 9600A/G/E/F System by adding standard modules to suit specific applications. The diagram at right shows the major functions, while modules available to perform those functions are illustrated and described with selection criteria on pages 10 through 22.

COMPUTATION AND SYSTEM CONTROL

Central element of HP 9600 series Systems is an HP 2100A digital Computer, designed specifically for convenient, flexible control of instrumentation systems. Memory and the number of input/output channels in this computer are plug-in expandable, allowing upgrading of the system to provide more capability as needs increase.

OPERATING SYSTEM AND SOFTWARE

The operating system is an HP-supplied program which makes the overall system work for data acquisition and control. In addition, HP supplies software for translating programs from source language (FORTRAN, ALGOL, or HP Assembler language) to computer language, and for editing and debugging of programs.

MEASUREMENT

For multiplexing and digitizing analog signals corresponding to temperatures, pressures, strains, etc., sensed by transducers, 9600 series Systems may be equipped with high speed and high resolution analog-to-digital subsystems. More than one analog subsystem may be used at the same time, say for concurrent high-resolution measurements of relatively static inputs, and high-speed analysis of dynamic analog signals. Data amplifiers are available for amplifying low-level transducer signals input to high speed subsystems.

DATA LOGGING, STORAGE, DISPLAY, AND PLOTTING

Data can be logged in various forms: a printout for immediately-readable 'hardcopy'; punched tape for data transmission or future computer analysis; IBM-compatible, 7- or 9-track magnetic tape for storage and later analysis on the HP computer or a larger central computing facility; magnetic disc (fixed head/track or removable cartridge type) for mass storage and future reference.

The basic 9600 series Systems all include a teleprinter and a high speed tape reader. These can be interchanged with, or

augmented by, other peripherals such as line printers, tape punches, magnetic tape units, and disc memories. Data can also be displayed or logged in graphical form on a keyboard-display terminal. X-Y CRT displays and new digital plotter are also available as standard peripheral options.

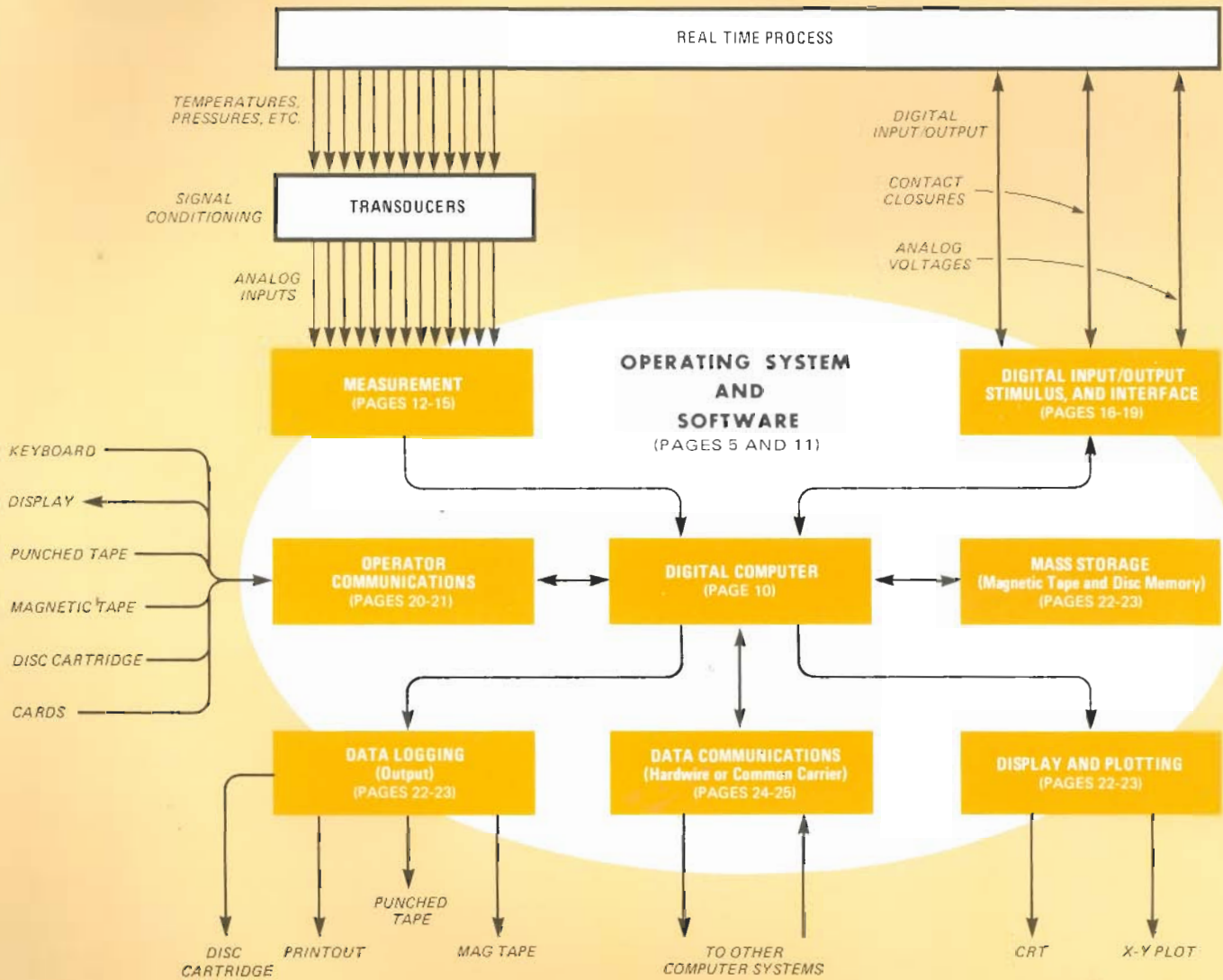
INTERFACING AND CONTROLLING EXTERNAL DEVICES

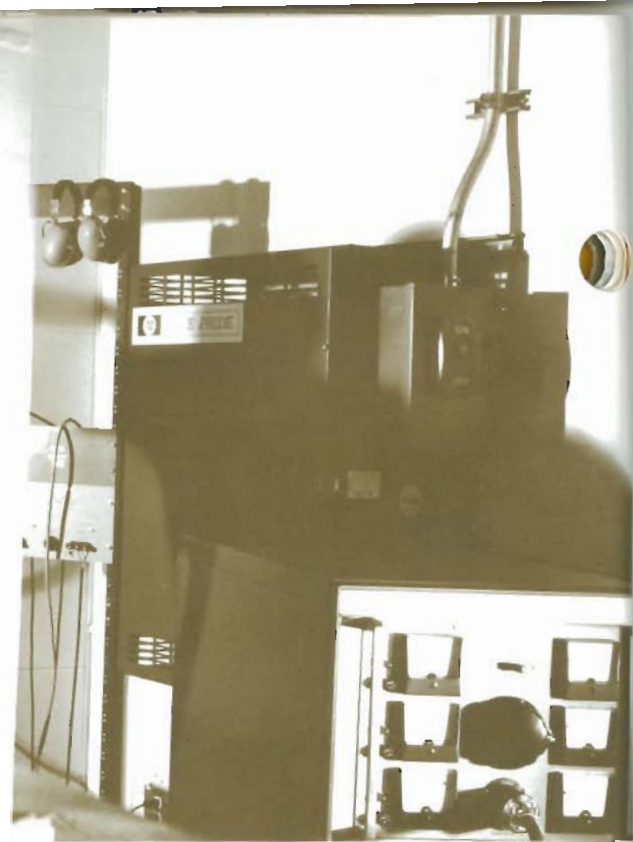
User-furnished equipment and digital inputs and outputs may be connected to the system through bi-directional registers, available in versions to operate with transistor and microcircuit equipment. For control of external circuits, hard-contact relay output registers or digital-to-analog converters may be used. *No special knowledge or understanding of the inner workings of the computer is required to make effective use of any of these interfaces.* Since up to 45 I/O channels are available with the computer, many external devices can be monitored and controlled, over and above the measuring instruments and peripherals comprising the basic system.

OPERATOR COMMUNICATIONS

Reference data and programs can be entered into 9600 series Systems in several ways — punched tape, magnetic tape, disc cartridge, mark-sense or punched cards, or manually via the keyboard of a teleprinter or keyboard-display (CRT) terminal, which can also be used to request data and programs previously stored on disc, or magnetic tape.

In the following pages, the capabilities of these system elements are described in more detail. The important concept is that an HP 9600 series System for Data Acquisition and Control is truly modular. Because standard hardware interfaces and software drivers are used for all system modules, the system can be assembled, expanded, or modified easily to handle different tasks as needs change, and thus yield maximum utility from your investment for years to come.





The Computer

Like other HP instruments, and like its predecessors (the HP 2114, 2115, and 2116 Computers), the HP 2100A computer that we use in 9600 series Systems is built to work, and keep on working, where people work - on the factory floor, aboard ship, and in aircraft, as well as in plush air-conditioned computer rooms. The photo above of a 2100A undergoing shake test illustrates just one of the environmental tests we put our computers through to assure that our 9600 series Data Acquisition and Control Systems will do *your* job at your site, reliably, hour-after-hour, day-after-day, for years to come. Hewlett-Packard doesn't offer a specially ruggedized computer for one simple reason: our standard models are rugged enough to work well in most applications without any special beefing up. This is confirmed by excellent reports from users of 9600 series Systems incorporating our 2114, 2115, and 2116 computers.

A microprocessor in its control section enables the 2100A to emulate all previous Hewlett-Packard Computers. As a result, 9600 series Systems benefit from more than 1,000 man-years of hardware and software development right from the start. Existing programs can be used on the newer 2100A-based systems, and system modules can be interchanged between other HP 9600 series Systems and 2100A-based 9600 series Systems. Other plus features of the ultra-flexible HP 2100A are:

- Memory plug-in expandable from 8K to 32K within the mainframe, in 4K increments to 16K, in 8K increments to 24K and 32K; this makes it easy to accommodate growing needs at any time, at your facility.
- 980 nanosecond memory cycle time for fast execution of programs.
- 14-channel input/output capacity in the mainframe is expandable to 45 channels with an I/O Extender, allowing for substantial growth of the system through plug-in I/O cards for interfacing additional instruments.
- Optional two-channel direct memory access can be assigned to any of the I/O channels in the system, including those in an input/output extender, for data transfer at rates to more than 1 million words/second.
- Optional floating point hardware speeds computations typically reducing computation times for scientific algorithms by a factor of 5 to 20.
- Power fail interrupt with auto restart, memory parity check with interrupt, and memory protect - features essential for systems use - are all standard.

Because the 2100A is a 16-bit machine sharing the same word structure, instruction repertoire, and software as its predecessors, existing programs written for 2114, 2115, and 2116 Computers are generally usable on the 2100A, assuming the equivalent memory configuration and processor options are used.

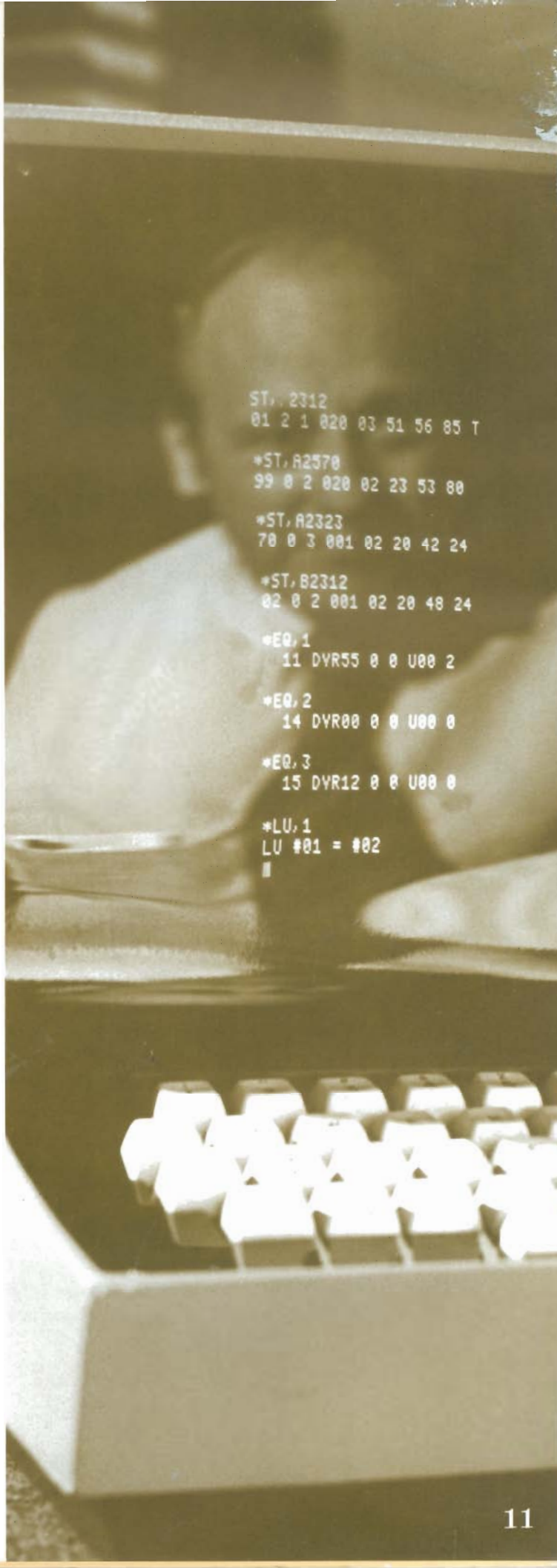
Additional information on the HP 2100A Computer is provided in brochures and a technical data sheet, available from Hewlett-Packard Field Sales Offices.

Software

The key to successful implementation of any data acquisition system is usually the capabilities of the software system supplied with the hardware. Without a strong software package centered around a strong central operating system, even the most state-of-the-art hardware is ineffective. In recognition of the key role played by software, Hewlett-Packard provides the most comprehensive software available for mini-computer controlled systems with 9600 series Data Acquisition and Control Systems. This package is based on your choice of the systems discussed on page 5, and includes FORTRAN and ALGOL Compilers, HP Assemblers, and source program editing and debugging routines. A comprehensive program library is included with each system. A FORTRAN IV compiler is available with HP 9600E/F Real Time Executive Systems. FORTRAN, ALGOL, and assembly language callable driver routines compatible with the selected system are furnished with most of the subsystems and peripheral modules shown in this brochure and with many of the interfaces. The FORTRAN and ALGOL compilers and the HP Assembler all generate relocatable object code, giving you the convenience of page-free programming and the ability to write programs in several FORTRAN, ALGOL, and Assembler language sections, which are automatically linked together when they are loaded.

System generation programs make it easy for you to modify your system as you add, delete, or change system peripherals. You don't have to rewrite programs as you add devices. Software is normally supplied in the form of punched tape. However, greatly increased speed and convenience of program assembly, compilation, editing, debugging, and loading is provided by the Magnetic Tape System (MTS), which is operable with Magnetic Tape Units which are optional in 9600 series Systems.

Hewlett-Packard 9600E/F Real Time Executive Systems offer the capability of *automatic* assembly, compilation, loading, and execution of programs in the "background". This activity takes place concurrently with the real time ("foreground") operations of the system. With these systems, programs can be added or deleted on-line without interrupting current operations.



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ST, 2312
01 2 1 020 03 51 56 85 T
*ST, A2570
99 0 2 020 02 23 53 80
*ST, A2323
70 0 3 001 02 20 42 24
*ST, B2312
02 0 2 001 02 20 48 24
*EQ, 1
  11 DYR55 0 0 U00 2
*EQ, 2
  14 DYR00 0 0 U00 0
*EQ, 3
  15 DYR12 0 0 U00 0
*LU, 1
LU #01 = #02
|
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High Speed Analog Voltage Measurements

Recovery of dynamic information from accelerometers and similar transducers, or sampling many channels of data with reasonable frequency, requires the use of a high-speed analog-to-digital subsystem to digitize the analog data. For this purpose in 9600 series Systems, Hewlett-Packard offers the subsystems shown on the facing page. Principal performance specifications of these subsystems are compared in the table below.

| SUBSYSTEM OPTION NUMBERS | RESOLUTION | MAXIMUM THROUGHPUT RATE TO BUFFER | FULL SCALE INPUT RANGE(S) | MAXIMUM NUMBER OF CHANNELS | ACCURACY |
|--------------------------|---------------------|-------------------------------------|---|--|--|
| F10 | 4 digits, BCD | 900 chan/sec | $\pm 0.1V, \pm 1V, \pm 10V$ | 10 to 50 single-ended, guarded inputs | $\pm 0.05\% \text{ fs}$ (0.1V range) $\pm 0.02\% \text{ fs}$ (1V, 10V ranges) |
| G00 | 12 bits, incl. sign | 44 kHz, via DMA, 12 kHz, non-DMA | $\pm 10.24V^*$ | 1056 single-ended or 528 differential inputs, with expanders | $\pm 0.09\% \pm \frac{1}{2} \text{ LSB}$ |
| G00/G20 | 12 bits, incl. sign | 12 kHz | $\pm 10 \text{ mV}$ to $\pm 10.24V$, (11 ranges) | 1024 low-level differential inputs with expanders | $\pm 0.41\% \text{ fs}$ to $\pm 0.18\% \text{ fs}$ |
| G60 | 10 bits, incl. sign | 100 kHz, DMA, 52 kHz, non-DMA | $\pm 1V, \pm 2.5V, \pm 10V^*$ | 16 single-ended inputs | $\pm 0.22\% \text{ fs} \pm \frac{1}{2} \text{ LSB}$ |
| G65 | 14 bits, incl. sign | 18 kHz, non-DMA | $\pm 10V^*$ | 64 single-ended inputs | $\pm 0.025\% \text{ fs} \pm \frac{1}{2} \text{ LSB}$ |

*Option D00 Dual-Channel System Data Amplifiers can be used to multiply full-scale sensitivity by the gain of 10, 100, or 1000, providing $\pm 1V, \pm 100 \text{ mV}$, or $\pm 10 \text{ mV}$ ranges, set by the fixed gain of the amplifier channel. The data amplifiers also provide input signal filtering with a choice of 10 Hz, 100 Hz, 1 kHz, 10 kHz, and 50 kHz jumper-selectable bandwidth.

SAMPLE-AND-HOLD AND PACING

Each measurement in a succession of digital values sampled by an analog-to-digital subsystem is useful only to the extent that it can be related to a previous real-time event, or to a previous measurement. When digital values are to be used for reconstruction or analysis of signal dynamics, the uniformity of sample-to-sample timing is particularly important. To assure minimum sample-to-sample timing variation with respect to measurement commands, all of the subsystems shown here, except the option F10 subsystem, are provided with a sample-and-hold circuit that holds subsystem timing variation (aperture) to no more than 30 to 100 nanoseconds. Further assurance of minimum timing variation is obtained by using a pacer to provide measurement commands with very low jitter. Overall, with use of an option G50 Programmable plug-in Pacer, the option G00 Subsystem, for example, achieves an absolute *system* aperture time of 50 nanoseconds total. Similar assurance of minimum timing variation in operation of the option G60, G64 and option G65 Subsystems can be obtained by using the G68 preset Pacer.

INPUT SIGNAL FILTERING

It is often essential to provide for rejection of undesired signal frequencies and superimposed noise, particularly on low-level analog inputs. In recognition of the need for noise rejection in high-speed analog measurements, HP provides input signal filtering in the option G00/G20 low-level multiplexing analog-to-digital system, with a choice of ten different cutoff frequencies and two-pole and three-pole filter designs. Input signal filtering is also incorporated in the option D00 Dual-Channel System Data Amplifiers, with a choice of four different cutoff frequencies that are jumper-selectable individually for each channel. The range of filtering choices offered makes it possible to satisfy the bandpass control requirements of most low-level inputs to HP high-speed analog-to-digital measurement subsystems.

MULTIPLE
LOW-LEVEL
ANALOG DATA
SIGNALS FROM
TRANSDUCERS

MULTIPLE
LOW-LEVEL
ANALOG DATA
SIGNALS FROM
TRANSDUCERS

DATA AMPLIFIER/CHANNEL



Option D00/D01
Data Amplifiers in Combining Case

MULTIPLE
HIGH-LEVEL
ANALOG DATA
SIGNALS



**HIGH-LEVEL MULTIPLE INPUT
ANALOG-TO-DIGITAL SUBSYSTEMS**



Option G00 ▲



Option G60 ■



Option G65 ■

DIGITAL
DATA



CONTROL



COMPUTER/CONTROLLER



2100A

- ▲ Programmable plug-in pacer (Option G50) is available for G00 Subsystem.
- Preset pacer (Option G68) is available.

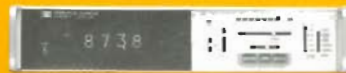
MULTI-LEVEL, MULTIPLE-INPUT ANALOG-TO-DIGITAL SUBSYSTEMS



Option G00/G20

Low Level
Multiplexer

ADC



Option F10

DIGITAL
DATA



CONTROL



High Resolution Measurements

VOLTAGE AND RESISTANCE MEASUREMENTS

In many industrial and research applications of data acquisition, the low-level analog output signals from thermocouples, strain gages, and other types of physical sensors change slowly. Where that is true, it is desirable to digitize the analog signals with a high-resolution analog-to-digital subsystem for two important reasons. First, the high-resolution subsystem provides maximum resolution for low-level measurements (1 microvolt on the 0.1 volt range) and optimum accuracy. Second, the high-resolution subsystem provides *superimposed noise rejection by integration during the measurement, avoiding the necessity for input signal filtering or for digital integration in the computer.*

In addition, guarded input in HP high-resolution subsystems rejects common mode noise. The combination of these noise rejection techniques preserves the excellent accuracy of HP high-resolution subsystems even in the presence of electrical noise from heavy machinery.

For 9600 series Systems, Hewlett-Packard offers the two subsystems shown on the facing page. Principal performance specifications of these subsystems are compared in the table below.

| SUBSYSTEM OPTION NUMBER | SAMPLE RATE - DC CHAN/SEC | FULL SCALE INPUT RANGES | ACCURACY | NUMBER OF CHANNELS | OPTIONAL FUNCTIONS |
|-------------------------|---------------------------|-------------------------------------|----------------------------|--------------------------------------|-------------------------------|
| E00 | 14 | 0.1V to 1000V (500V, max. input) | 0.01% rdg \pm 0.005% fs | 200 3-wire, expandable to 1000 | AC Resistance Frequency |
| E01 | 40 | 0.1V to 100V | 0.012% rdg \pm 0.005% fs | 10 3-wire, expandable to 1000 | AC Frequency |

MULTIPLE ANALOG DATA SIGNALS FROM THERMOCOUPLES STRAIN GAGES, OR OTHER PHYSICAL SENSORS



TIME INTERVAL AND FREQUENCY MEASUREMENTS

For measurement of the relative timing and frequency of physical events in 9600 series Systems, Hewlett-Packard offers a choice of four different 7-digit Timer-Counter-DVM subsystems. The principal performance specifications of these subsystems are compared in the table below.

| SUBSYSTEM OPTION NO(S) | MEASUREMENT CAPABILITIES | ATTENUATION PROGRAMMING |
|------------------------|--|-------------------------|
| H01 | Frequencies to 50 MHz. Single intervals 0.1 μ s to 10 ⁹ sec. Avgd intervals 0.15 ns to 10 sec. | No |
| H07 | DC voltage on \pm 10V/100V/1000V range. | Yes |
| H04 | Frequencies to 550 MHz. Single intervals 0.1 μ s to 10 ⁹ sec. Avgd intervals 0.15 ns to 10 sec. | No |
| H09 | DC voltage on \pm 10V/100V/1000V range. | Yes |

FREQUENCY INPUT OR START OF INTERVAL



STOP INTERVAL



**MULTI-LEVEL, MULTIPLE-INPUT ANALOG-TO-DIGITAL SUBSYSTEMS
FOR VOLTAGE AND RESISTANCE MEASUREMENTS**



Option E00



Option E20

COMPUTER/CONTROLLER

SCANNER
PROGRAM



DVM
PROGRAM



DIGITAL
DATA



2100A

TIME INTERVAL AND FREQUENCY MEASUREMENTS



Option H01, H07



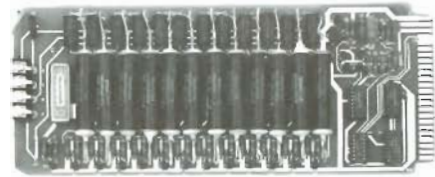
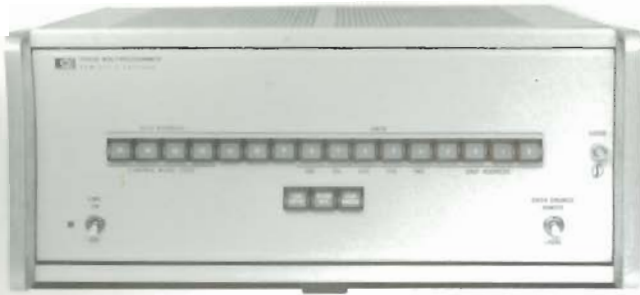
Option H04, H09

DIGITAL
DATA



CONTROL





Digital Input/Output

HP 9600 series Data Acquisition and Control Systems often must respond to external contact closures and other digital inputs. In addition, systems may have to provide contact closures or other digital outputs for control of external equipment. To satisfy requirements for digital input and output, Hewlett-Packard offers the seven plug-in interfaces and subsystems described on these two pages. Every one of the interfaces includes priority interrupt capability. The services of HP system analysts are available for preparation of driver routines tailored to your requirements for digital input/output.

INTERFACES

Digital Input, without storage, for up to 32 bits is provided by a Data Source Interface. This card is designed to provide an economical means of connecting multiple contact closures, control, or status inputs to the computer from console switches, limit switches on controlled equipment, or similar sources. One of the most significant features of this interface is its input versatility. The '1' and '0' input levels may range from +100V to -100V, and the separation between levels may range from 5V up to 100V.

Digital Input/Output, for bi-directional transfer of control and status information via a single cable and a single interface card position in the computer, is available with the user's choice of four different duplex registers. Sixteen-bit input/output at TTL- or DTL-compatible integrated-circuit logic levels, with a further choice of either ground-true or positive-true logic, is provided by a Microcircuit Interface. Two other duplex registers give 16-bit and 8-bit input/output, respectively, at transistor logic levels. The user can choose either positive-false (NPN) or negative-true (PNP) logic with either of these interfaces.

11-Bit Digital Input and 24-Bit Digital Output are provided by a DVS Programmer interface. This interface is available in two different versions: one compatible with transistor logic levels, the other compatible with integrated circuit logic levels.

Relay Contact Closure Output is available for applications in which external equipment must be isolated from the computer. A Relay Output Register provides 16 individual floating contact closures that permit flexible use of output bit states in addition to assuring isolation from computer ground. A command channel with both contact closure and transistor driver inputs and outputs is included. Applications include energizing of control actuators (either directly or through intermediate relays); control of power supply output, amplifier gain, or amplifier response by switching of control loop resistances, inductances, or capacitances; and energizing of remote indicators.

40-Bit Digital Output for control situations requiring greater precision than 24 bits is offered by a 40-Bit Register. This register provides a most economical means of connecting multiple bit states from the computer to indicators and other external circuits. Both positive-true and positive-false (NPN) logic is available.

MULTIPROGRAMMER SUBSYSTEMS

Great expansion of the digital input/output capabilities of 9600 series Systems is provided by a Multiprogrammer Subsystem and a Multiprogrammer Extender. The Multiprogrammer provides 15 channels which may be used for 12-bit digital input/output. These are connected to the computer via a single input/output interface. The basic digital input/output capacity of the Multiprogrammer can be further extended to as many as 240 channels through the use of up to 15 Multiprogrammer Extenders. The versatile Multiprogrammer Subsystem accepts the following plug-in digital input/output cards:

- Digital Input Card – monitors 12 lines of TTL, DTL, or RTL, or contact closure logic. Includes external gate and flag.
- Telephone Relay Monitor Card – monitors 12 lines of TTL, DTL, or TRL, or contact closure logic, and can withstand transients up to 1500V without damage. Includes external gate and flag.
- TTL Output Card – provides 12 bits at TTL/DTL logic levels.
- Relay Output Card – provides 12 isolated, independent SPST contact pairs with 3.5 millisecond pull-in, 1 millisecond release time.
- Relay Output Card With Read-Back Card – provides same capability as Relay Output Card, above, but with lines monitoring status (energized/not energized) of the relays.

NOTE: The Multiprogrammer Subsystem and Multiprogrammer Extender may also be used for analog output control, as noted on page 18.

Additional information on these interfaces and subsystems is contained in the following technical data sheets which are available from Hewlett-Packard Field Sales Offices:

| <i>9600 Series Option(s)</i> | <i>Data Sheet</i> |
|----------------------------------|---|
| <i>J00</i> | <i>12604B General-Purpose Data Source Interface</i> |
| <i>S04-S06</i> | <i>12566A 16-bit Microcircuit Interface</i> |
| <i>S00-S03</i> | <i>12554A/97A 16/8-bit Duplex Register</i> |
| <i>K06</i> | <i>12551B Relay Output Register</i> |
| <i>K00</i> | <i>12556B 40-Bit Register</i> |
| <i>K08, K09</i> | <i>12661A DVS Programmer</i> |
| <i>T17, T18</i> | <i>6940A/41A Multiprogrammer System</i> |



Stimulus and Control

The stimulus and control functions of HP 9600 series Data Acquisition and Control Systems are provided in the form of analog and digital outputs. To satisfy a diversity of control requirements, Hewlett-Packard offers the digital (dc) voltage sources, and multiprogrammer presented in this section and the digital input/output interfaces and subsystem shown on pages 16 and 17. The services of HP system analysts are available through HP Data Centers for preparation of driver routines tailored to the stimulus and control needs of your system.

DIGITAL VOLTAGE SOURCES

Digitally programmed analog (dc) control voltages can be provided by your choice of Digital Voltage Sources (DVS). When loaded resistively, the output voltage from any of these digital voltage sources settles within 0.1% of the programmed voltage change within 300 microseconds. Change of voltage range requires 2 milliseconds. Up to eight DVSs can be operated from the same computer interface. Voltage, polarity, and current limits are all programmable. Output resolution is 0.5 millivolts on the low range, 5 millivolts on the high range.

| 9600 SERIES OPTION NO. | OUTPUT VOLTAGE | OUTPUT CURRENT |
|---------------------------|-------------------|-------------------|
| I30 | 0 to $\pm 50V$ | 0 to 1A |
| I36 | 0 to $\pm 50V$ | 0 to 5A |
| I32 | 0 to $\pm 100V$ | 0 to 0.5A |

MULTIPROGRAMMER AND EXTENDER

A far greater range of control flexibility is afforded by the Multiprogrammer and the Multiprogrammer Extender. The Multiprogrammer exchanges control and status information with the computer via a single interface card, and distributes control signals to 15 different control output cards in its own mainframe. In addition, the control information received by the Multiprogrammer can be further distributed to as many as fifteen Multiprogrammer Extenders, each capable of operating fifteen control output cards within its mainframe. Thus one computer interface can output control information through up to 240 individually-addressable and programmable 12-bit output channels. These versatile multiprogrammer units accept plug-in cards for:

- Resistance Output for control of power supply voltages and currents. This capability is useful for setting the speed of dc motors, controlling the temperature of heaters, etc., with 12-bit (1 part in 4096) resolution.
- Low Speed Digital-to-Analog Conversion with 10 bit plus sign resolution of the span from -10.24 to +10.23 volts dc, with through-zero programming. The analog output requires 6 milliseconds to settle within 10 millivolts of final value.
- High Speed Digital-to-Analog Conversion with 11 bit plus sign resolution of the span from -10.24 to +10.235 volts dc, with through-zero programming. Time for programming and settling of the output within 5 millivolts of final value is 60 microseconds.

Additional information on these stimulus and control instruments is provided in the following data sheets, which are available from Hewlett-Packard Field Sales Offices.

| 9600 Series Option(s) | Data Sheet |
|--------------------------|--|
| I30, I32, I36 | 6129A/30B/31B Digitally Controlled Voltage Sources |
| T17, T18 | 6940A/41A Multiprogrammer System |

Interfacing to User-Furnished Instruments

HP 9600 series Data Acquisition and Control Systems often must operate with instruments furnished by the user. Six standard, plug-in interfaces for data input, data input/output, program output, and analog output are offered by Hewlett-Packard to meet the interface and control requirements of user's equipment. Every one of these interfaces includes priority interrupt capability. No special knowledge or understanding of the inner workings of the computer is required to make effective use of any of these interfaces. The services of HP system analysts are available through HP Data Centers to help you prepare driver routines tailored to the requirements of the interfaced equipment.

Data Input, without storage, for up to 32 bits (eight BCD digits) is provided by a Data Source Interface. This card is designed to interface digital measuring instruments to the computer. One of the most significant features of this interface is its input versatility. The '1' and '0' input levels may range from +100V to -100V, and the separation between levels may range from 5V up to 100V.

Data Input/Output, for bi-directional transfer of status and control information via a single cable and a single interface card position in the computer, is available with the user's choice of three different duplex registers. Sixteen-bit input/output at TTL- or DTL-compatible integrated-circuit logic levels, with a further choice of either ground-true or positive-true logic, is provided by a Microcircuit Interface. Two other duplex registers give 16-bit and 8-bit input/output, respectively, at typical transistor logic levels. The user can choose either positive-false (NPN) or negative-true (PNP) logic with either of these interfaces.

40-Bit Output for instrument programming requiring greater precision than 16 bits is offered by a 40-Bit Register. This register is also used for outputting up to 10 BCD digits to the HP 5050B Digital Recorder or to Hewlett-Packard Frequency Synthesizers via the HP 2759B Frequency Synthesizer Programmer. Both positive-true and positive-false (NPN) logic is available.

Analog Output is provided by a Dual 8-Bit Digital-to-Analog Converter. This card is designed primarily for driving oscilloscopes, X-Y displays, and X-Y plotters that respond to analog input. It provides two 0 to 10V analog outputs, each resolved to 1 part in 256.

Additional information on these interfaces is contained in the following technical data sheets which are available from Hewlett-Packard Field Sales Offices:

| <i>9600 Series Option(s)</i> | <i>Data Sheet</i> |
|----------------------------------|---|
| <i>J00</i> | <i>12604B General-Purpose Data Source Interface</i> |
| <i>S04, S05</i> | <i>12566A Microcircuit Interface</i> |
| <i>S00-S03</i> | <i>12554A/97A Duplex Register</i> |
| <i>K00</i> | <i>12556B 40-Bit Register</i> |
| <i>I29</i> | <i>12555B Digital-to-Analog Converter</i> |

Operator Communications

TELEPRINTERS

Teleprinters are the most versatile peripheral available for the operator to communicate with the system, to enter programs and reference data and print out and punch reduced data and programs. They provide tape read/punch capability and a hard copy printed record, in addition to the operator's keyboard. The principal disadvantage of the teleprinter is its slowness; it operates at a 10 character per second data rate. For this reason, 9600 series Systems are equipped with a high speed tape reader in addition to the teleprinter. This speeds compilation and input of programs. This same purpose can also be served by supplementing the teleprinter with mark-sense or punched card, magnetic tape, or disc peripherals. Nevertheless, even when supplementary equipment is used, the teleprinter may retain an important role as a system control terminal. Hewlett-Packard offers two different teleprinters for operator communication. One of these (a modified Teletype ASR-33) is the standard operator communications terminal in 9600 series Systems. The other is a heavy-duty unit (a modified Teletype ASR-35), which can be supplied in place of the standard teleprinter. The heavy-duty teleprinter is recommended for use expected to exceed about 5 hours per day or 30 hours per week.

KEYBOARD-DISPLAY TERMINAL

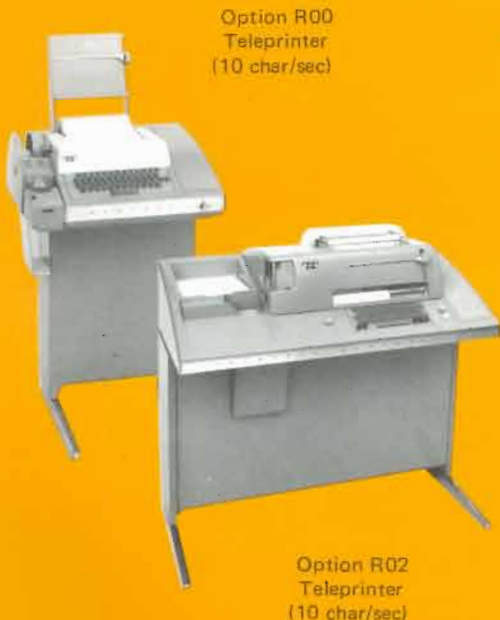
In 9600 series Systems using a console printer or line printer to provide hard copy, a Keyboard-Display terminal offers fast, quiet communication between the operator and the system. This system control terminal operates at 20 times the speed of the teleprinter it replaces and displays 25 lines, with up to 72 characters per line.

CONSOLE PRINTER

Faster operator-system communication, with printout in a wider format, is provided by a Console Printer. This printer operates at 3 times the speed of the teleprinter and prints up to 132 characters per line (vs 72 characters per line with the teleprinter).

PUNCHED TAPE

To provide fast read-in of punched tapes, 9600 series Systems are equipped with a high speed Punched Tape Reader. This reader operates at 50 times the rate of the teleprinter, greatly speeding compilation or assembly and input of programs and reference data.



Option R06
Console Printer
(30 char/sec)



Option R04
Keyboard-Display Terminal
(200 char/sec)

Option Q00
Tape Reader
(500 char/sec)



CARD INPUT

For entry of programs and data from 12-level mark-sense or punched cards, your system can be equipped with an Optical Mark Reader. This unit reads 200 cards per minute and is capable of reading both marked and punched cards meeting HP 2760A/61A tab card specifications. Faster input, from 80-column punched cards only, is provided by a Card Reader that reads 600 cards per minute.

MAGNETIC TAPE INPUT

Storage of system software on magnetic tape enables programs to be compiled, edited, and input to the system far more quickly and conveniently than with punched tape. This capability is provided by a choice of 24 different Magnetic Tape Units, available in 7- and 9-channel versions, with tape speeds ranging from 12.5 to 45 ips, at densities up to 1600 cpi, yielding data read/write rates up to 72,000 characters per second.

CARTRIDGE DISC INPUT

System software can also be stored on interchangeable disc cartridges and entered into the computer via a Moving Head Disc Memory Unit. At 122,880 16-bit computer words per second, the data rate of this peripheral offers the fastest entry of programs and data into the computer. Direct Memory Access is required with disc memory units.

Additional information on these peripherals is provided in the following technical data sheets, which are available from Hewlett-Packard Field Sales Offices:

| 9600 Series Option(s) | Data Sheet |
|-----------------------|---|
| R04 | 2600A Keyboard-Display Terminal |
| R06 | 2605A Console Printer |
| R00, R02 | 2752A/54B Buffered Teleprinter Input/Output |
| Q00 | 2748A Punched Tape Reader |
| Q28 | 2761A-007 Parallel Output Optical Mark Reader |
| Q20 | 2892A Card Reader |
| Q70 | 7900A Disc Drive |
| Q40-Q63 | 7970A Digital Magnetic Tape Unit |



Option Q28
Optical Mark Reader
(200 cards/min)



Option Q70
Cartridge Disc Memory
(122,880 words/sec)



Option Q20
Card Reader
(600 cards/sec)



Option Q40-Q63
Magnetic Tape Unit
(72,000 char/sec)

Data Logging, Storage, Display, and

PRINTOUT



Option R50
Line Printer
(80 col, 356 lines/min)

Peripherals for direct printout include a choice of two teleprinters, a console printer, and two line printers. The teleprinter combines a typewriter, tape punch, and tape reader in the simplest complete input/output device for the computer. Two models are offered: a modified Teletype ASR-33, which is standard equipment in 9600 series Systems, and the heavy-duty unit (a modified Teletype ASR-35), which is the recommended alternate for usage in excess of 5 hours per day or 30 hours per week. Both of these teleprinters operate at 10 characters per second.

Three times the speed of the teleprinter and 132-column format is provided by a Console Printer (photo on page 20). This is available without keyboard for data logging use only.

For maximum printout rate, a high-speed line printer is recommended. A unit is available which prints 80 columns per line at a rate of 356 lines per minute, or up to 1,000 lines per minute with only 20 columns per line. An alternate line printer prints 132 columns per line at a rate of 200 lines per minute.



Option R52
Line Printer
(132 col, 200 lines/min)

```

TEST - PUMP TEST
DATE - 8-22-67
TEST START TIME - 09:17:23

INITIAL CONDITIONS

TIME      PUMP  RPM  POWER  OUTPUT  OUTPUT  EFF.  MOTOR  BEARING  TEMP
          NO.   0W   INPUT  FLOW    PRESS.  TEMP  #1     #2
09:17:58  1     0    0W     0       0       0    77.3F  77.7F  77.8F
09:18:09  2     0    0W     0       0       0    77.5F  78.1F  79.9F
09:18:19  3     0    0W     0       0       0    63.4F  61.5F  62.8F

PUMPS START - 09:18:30

09:19:00  1  3621  986W   237.6   78.3   45.7  77.4F  77.9F  77.9F
09:19:11  2  3588  976W   243.5   76.5   47.2  77.6F  78.3F  80.4F
09:19:21  3  3603  1026W  249.9   76.6   47.1  63.6F  61.7F  62.2F

09:24:00  1  3635  981W   239.2   78.5   46.1  85.3F  81.2F  80.7F
09:24:11  2  3542  975W   241.8   76.2   46.3  86.2F  81.8F  116.8F
09:24:21  3  3627  1015W  251.3   76.9   47.4  81.3F  66.4F  67.1F

TROUBLE - PUMP NO. 2 - BEARING #2, OVERTEMP - PUMP IS SHUT DOWN
09:27:51  2  2731  1073W  197.2   53.6   28.9  92.6  63.1F  198.7F

09:29:00  1  3641  979W   240.6   78.6   46.3  91.7F  84.1F  84.1F
09:29:11  2     0    0W     0       0       0    91.5F  83.3F  182.9F
09:29:21  3  3633  1007W  251.7   77.0   47.6  88.6F  69.2F  69.9F
    
```

Typical test log typed out by teleprinter illustrates how data can be formatted for easiest reading. In this application, system was monitoring output and operating conditions of three motor-driven pumps. Note system shut down motor with overheated bearing, and printed message to operator indicating this has been done.



Option Q03
Tape Punch
(120 char/sec)

PUNCHED TAPE

Although the teleprinter offers both input and output punched tape capability, its data rate is usually too slow for data logging on punched tape. For faster data logging on punched tape, HP 9600 series Systems can be equipped with a tape punch, which logs data at 7.5 times the speed of the teleprinter, or one that punches tape at 12 times the speed of the teleprinter.



Option Q05
Tape Punch
(175 char/sec)

MAGNETIC TAPE

Data logging and mass storage on magnetic tape is provided by Magnetic Tape Units, which are available in 7- and 9-track versions, with tape speeds ranging from 12.5 to 45 ips, and densities up to 1600 epi, for data read/write rates up to 72,000 characters per second. These read/write tape units can be used for temporary storage of data throughput onto tape which is later read back into the computer for analysis. Up to four tape units can be operated through the same interface.

Plotting

DISC STORAGE

Fastest read/write communication with mass storage is obtained with disc memory units. Of the units available, the most economical is a Moving Head Disc Drive Unit, which is standard in 9600E Systems. In this unit, an interchangeable disc cartridge and a fixed disc together store 2.5 million words with average access time of less than 50 milliseconds and 122,880 words/second transfer rate. Up to three additional disc drives, operated from the same controller, can be used to increase storage capacity to 10 million words. Faster access, 17.6 milliseconds, maximum, with storage capacity ranging from 262,000 to 1,048,000 words is obtained with fixed-head-per-track Disc Memories, at transfer rates to 118,000 words/second. The fixed-head-per-track disc memory is standard in 9600F Systems. Direct Memory Access is required with disc memory units.

DATA DISPLAY AND PLOTTING

Interpretation of data gathered and processed by the system is often simplified by graphic presentation. One means of providing such presentation is on X-Y display units, of which HP offers a choice of two. The largest of these is the 8 x 10 inch X-Y Display. The other is an 8 x 10 centimeter X-Y Display with high-intensity storage that minimizes display refresh time. Both of these displays feature 1 part in 256 resolution along the X and Y axes. Annotations can be added easily, with the character and graph generator software that is supplied with either display.

Permanent X-Y recordings on a 10 x 15 inch writing area can be obtained with a new Graphic Plotter that offers resolution of 1 part in 10,000 on X and Y axes. This new absolute address digital plotter has an average writing speed of 10 inches per second. The character and graph generating software for this plotter requires only 900 words of memory.

Additional information on these peripherals is provided in the following technical data sheets, which are available from Hewlett-Packard Field Sales Offices:

| 9600 Series Option(s) | Data Sheet |
|--------------------------|---|
| R82 | 1331C X-Y Displays |
| R81 | 2331A X-Y Display Subsystem |
| R06, R07 | 2605A Console Printer |
| R52 | 2610A Line Printer |
| R00, R02 | 2752A/2754B Buffered Teleprinter Input/Output |
| Q03 | 2753A High Speed Punched Tape Output |
| Q80-Q83 | 2766A Disc Memory |
| R50 | 2767A Line Printer |
| Q05 | 2895A Punched Tape Output |
| R85 | 7210A Graphic Plotter |
| Q70-Q71 | 7900A Disc Drive |
| Q40-Q63 | 7970 Digital Magnetic Tape Unit |



Option Q70
Disc Drive
(2.5 million words, 122,880 words/sec)



Option Q80
Disc Memory
(262K words, 118,000 words/sec)



Option R81
X-Y Display Subsystem



Option R82
X-Y Display Subsystem
(with high intensity storage)



Option R85
Graphic Plotter

Distributed Data Acquisition and Control Systems

Data must often be acquired from widely-separated locations in industrial plants and research laboratories, and control signals and operator information must be returned to those locations. In most instances, it is impractical and costly to run hundreds of feet of multiple analog and digital signal cables to connect transducers, control devices, and teleprinters at remote sites to a central computer system. One answer to the need for local facilities is to establish a small computer system at each site. This keeps cable runs short and provides local information to the operator, but leaves the actions taking place at the various sites uncoordinated, and does not provide for accumulation of data from those sites at a central point. Now, however, Hewlett-Packard has developed new data communications interfaces which can be used to tie remote data acquisition and control sites into one unified, distributed system coordinated at a central location. These interfaces are supplied complete with software driver routines for simplified programming, and can be used for data transfers over distances up to nearly two miles (three kilometers).

AN OUTLINE OF THE DISTRIBUTED SYSTEM

In the distributed system, a central 9600 series System coordinates the data acquisition instruments, control elements, and operator communications at the remote sites through the data communications interfaces and *remote terminals*. Each remote terminal receives control information from, and returns data to, the central computer via a data communication interface kit and only two shielded twisted pair wires. The central system is generally equipped with mass storage, fast data logging, and operator communications peripherals. In addition, the central system may have displays or plotters for graphic presentation of overall system operations. The remote terminals are equipped with data acquisition instruments, control outputs, and a teleprinter or keyboard-display terminal for operator-system communication at the remote site. This 'mix' of central system and remote site capabilities satisfies overall requirements of the distributed system at minimal cost.

COUPLER/CONTROLLERS AS REMOTE TERMINALS

For fairly simple remote site operations requiring only a few control and measuring instruments, HP 2570A or 2575A Coupler/Controllers communicating through data communications interfaces, can be used as remote terminals at surprisingly low cost. In this service, the 2570A can coordinate up to seven devices under control of the central computer; the 2575A handles three devices. The Coupler/Controllers interface with more than 25 different measurement and stimulus instruments. Data transmission rate between the central system and coupler/controller remote terminals is inversely proportional to distance. Over a distance of 600 feet (182 meters), the rate is 4,100 coupler words (characters or numbers) per second. At this rate, the coupler/controller can transmit up to 500 eight-digit* measurements per second to the central system. Even at a distance of 10,000 feet (3 km), the transmission rate is fast enough to transmit 100 eight-digit measurements per second.

* 6 data digits, plus range and function digits.

COMPUTERS AS REMOTE TERMINALS

More complex remote site operations, involving more than seven devices, must be handled by 2100A Computers serving as remote terminals. In addition to the greater number of input/output channels provided by the computer, its memory, computational power, and decision-making capability can be used to perform most of the control and data acquisition functions at the remote site autonomously, and to process and concentrate data prior to transmission to the central system. Data communication rates with computer remote terminals are considerably faster than with coupler/controllers. With Direct Memory Access (DMA) in both the remote computer and central system, up to 34,500 computer words per second can be transmitted over 600 feet (182 meters); this is equivalent to 16,250 eight-digit* measurements (translated to floating point form in the computer). At a distance of 10,000 feet (3 km), the transmission rate is 1,600 words per second using DMA, fast enough to transmit 800 eight-digit measurements per second. The maximum rate without DMA is 5,200 words per second at 600 feet, 1,200 words per second at 10,000 feet. The 2100A as remote terminal works with any of the subsystems, instruments, interfaces, and peripherals described in this brochure.

* 6 data digits, plus range and function digits.

COMMON-CARRIER CAPABILITIES

In addition to the communications interfaces discussed above, Hewlett-Packard also offers four computer-to-computer data set interfaces for use with common-carrier communications facilities. These make it possible for HP 9600 series Systems to exchange data and control information with remote terminals, with each other, or with larger computers over long distances. The interfaces offered provide for asynchronous communication at rates to 60 computer words per second, for synchronous communication at rates to 480 computer words per second, and for operation of compatible automatic dialing equipment.



MARKETING



ENGINEERING



SHOP



SHIPPING



TEST



PRODUCTION

Additional information on these interfaces and remote terminals is provided in the following publications, which are available from Hewlett-Packard Field Sales Offices.

| 9600 Series Option(s) | Data Sheet |
|--------------------------|--|
| U07, U08 | 12770A/12771A 2570A/2575A |
| P00 | 2100A |
| U01-U05 | 12587A, 12589A, 12618A, 12621A, 12622A |

*Serial Data Communications
Coupler/Controllers
Computer
Data Communication Interfaces
for HP Computers*



Hewlett-Packard Support for your System

Our Commitment to Your Success

Hewlett-Packard's commitment to your successful application of 9600 series Computer Data Acquisition Systems begins with a careful analysis of your system requirements and expert counseling on your system's configuration. Equally careful attention is given to assembly of your system, installation, final checkout, and after-sale support. This minimizes the risk involved in complex system integration. Your main effort can be directed toward preparation of the application programs to be run on your system and connection of real-time process inputs and outputs to your system.

Training

HP provides a two-week user (programming) training course with every 9600 series Computer System. The course covers FORTRAN and HP Assembler language programming and the Basic Control System. Follow-on training in Data Acquisition System Programming (a four-day course) is provided with 9600G Systems; a one-week course dealing with the special aspects of programming in Real Time Executive systems is included with the purchase of 9600E/F Systems. All instruction includes hands-on experience. HP computer maintenance training courses are also offered for those customers planning to maintain their own systems.

Documentation

HP is well-known for the quality and thoroughness of its operating and service manuals, and the documentation provided with our 9600 series Computer Data Acquisition Systems is in that tradition. The documentation provided includes programmer's reference manuals for the software furnished, operating procedures, and technical descriptions with diagnostic and maintenance procedures for hardware furnished. In addition, available through local HP sales offices is information on how to order a comprehensive set of programming guides, a complete, four-part program catalog, and software publications.

Data Centers

Four regional data centers in the U.S., one in Canada, one in Mexico, one in Brazil, four in Europe, one in Japan, and one in Australia have been established to meet the unique needs of HP computer system users. These locations are highlighted in the list of world-wide sales and service offices on the rear page. At these centers, you can purchase the assistance of experienced system engineers and system analysts in the development of specialized solutions to your data acquisition and control applications.

Service

Service and parts assistance are supported by some 700 people comprising the HP customer service organization. More than 80 HP field sales offices located in North America and abroad provide rapid and convenient service for Hewlett-Packard systems. Customers need not correspond with a factory several thousand miles away for service, replacement parts, and technical assistance. Backing up local offices are four regional service centers in the United States and major service centers in both the United States and Europe. Board exchange programs for computers and other complex instruments enable systems to be returned to normal service with minimal down-time.

System Warranty

All Hewlett-Packard electronic measuring systems, including the instruments, peripherals, and supported software which are a part thereof, are warranted to be free from defects in material and workmanship for a period of 90 days. We will repair or replace, without charge, products which prove to be defective during the warranty period. Warranty service will be performed on-site at the customer's facility in the United States, Canada, and Western Europe and in other designated locations near qualified HP service facilities. No other warranty is expressed or implied. Hewlett-Packard is not liable for consequential damages.

Service Agreements

Hewlett-Packard's way of assuring that you get maximum utilization of your system is through Customer Service agreements. The HP Customer Service Agreement makes the expertise and resources of the HP service organization available at your plant whenever they are needed. The Customer Service Agreement frees you from the problems of finding and training capable maintenance personnel, stocking parts, obtaining and maintaining test equipment, and additional supervisory tasks, all at a known annual cost.

Hewlett-Packard Customer Service Representatives perform both Preventive Maintenance and Remedial Maintenance on-site. Preventive Maintenance insures that your system is always in first-class operating condition. The Preventive Maintenance schedule is tailored for each type of system, and benefits from our detailed understanding of the needs for each of our system components. Regularly scheduled Preventive Maintenance often corrects potential problems before they occur. For remedial maintenance if a malfunction occurs, your HP Customer Service Representative is only a phone call away, and since he has regularly maintained your system, he is familiar with it and hence able to determine the problem and return your system to useful service in the shortest possible time.

Several optional coverages are available for Remedial Maintenance, ranging from normal working hours Monday through Friday to three shift coverage, seven days per week. In addition to standard options, custom tailored features can be developed in consultation with your local HP service facility.

World-Wide Hewlett-Packard Sales and Service

Call your HP System Sales Engineer at any of these convenient locations:

UNITED STATES

ALABAMA
Huntsville
Tel: (205) 881-4591

ARIZONA
Phoenix
Tel: (602) 252-5061
Tucson
Tel: (602) 298-2313

CALIFORNIA
★ Fullerton
Tel: (714) 870-1000
North Hollywood
Tel: (213) 877-1282
Palo Alto
Tel: (415) 327-6500
Sacramento
Tel: (916) 482-1463
San Diego
Tel: (714) 279-3200

COLORADO
Englewood
Tel: (303) 771-3455

CONNECTICUT
East Hartford
Tel: (203) 289-9394
Norwalk
Tel: (203) 853-1251

FLORIDA
Ft. Lauderdale
Tel: (305) 731-2020
Orlando
Tel: (305) 841-3970

GEORGIA
★ Atlanta
Tel: (404) 436-6181

ILLINOIS
★ Skokie
Tel: (312) 677-0400

INDIANA
Indianapolis
Tel: (317) 546-4891

LOUISIANA
Kenner
Tel: (504) 721-6201

MARYLAND
Baltimore
Tel: (301) 944-5400
Rockville
Tel: (301) 948-6370

MASSACHUSETTS
Lexington
Tel: (617) 861-8960

MICHIGAN
Southfield
Tel: (313) 353-9100

MINNESOTA
St. Paul
Tel: (612) 645-9461

MISSOURI
Kansas City
Tel: (816) 763-8000
St. Louis
Tel: (314) 962-5000

NEW JERSEY
★ Paramus
Tel: (201) 265-5000
Cherry Hill
Tel: (609) 667-4000

NEW MEXICO
Albuquerque
Tel: (505) 265-3713
Las Cruces
Tel: (505) 526-2485

NEW YORK
Albany
Tel: (518) 869-8462
Endicott
Tel: (607) 754-0050
Poughkeepsie
Tel: (914) 454-7330
Rochester
Tel: (716) 473-9500
Syracuse
Tel: (315) 454-2486
Woodbury
Tel: (516) 921-0300

NORTH CAROLINA
High Point
Tel: (919) 885-8101

OHIO
Cleveland
Tel: (216) 835-0300
Columbus
Tel: (614) 846-1300
Dayton
Tel: (513) 298-0351

OKLAHOMA
Oklahoma City
Tel: (405) 848-2801

OREGON
Portland
Tel: (503) 292-9171

PENNSYLVANIA
Monroeville
Tel: (412) 271-0724
King of Prussia
Tel: (215) 265-7000

RHODE ISLAND
East Providence
Tel: (401) 434-5535

TEXAS
Richardson
Tel: (214) 231-6101
Houston
Tel: (713) 781-6000
San Antonio
Tel: (512) 434-4171

UTAH
Salt Lake City
Tel: (801) 487-0715

VERMONT
South Burlington
Tel: (802) 658-4455

VIRGINIA
Richmond
Tel: (703) 285-3431

WASHINGTON
Bellevue
Tel: (206) 454-3971

WEST VIRGINIA
Charleston
Tel: (304) 768-1232

CANADA

ALBERTA
Edmonton
Tel: (403) 482-5561

BRITISH COLUMBIA
North Burnaby
Tel: (604) 433-8213

MANITOBA
Winnipeg
Tel: (204) 786-7581

NOVA SCOTIA
Halifax
Tel: (902) 455-0511

ONTARIO
Ottawa
Tel: (613) 225-6530
Rexdale
Tel: (416) 677-9611

QUEBEC
★ Pointe Claire
Tel: (514) 697-4232

EUROPE

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BELGIUM
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FINLAND
Helsinki

FRANCE
★ Orsay
Lyon
Blagnac

GERMANY
Berlin W
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★ Frankfurt
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NETHERLANDS
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SWEDEN
Möndal
Bromma

SWITZERLAND
Schlieren-Zurich
Meyrin-Geneva

UNITED KINGDOM
Altrincham, Cheshire
★ Slough, Bucks

FOR EUROPEAN AREAS NOT LISTED, CONTACT:

Hewlett-Packard S.A.,
Rue du Bois-du-Lan 7,
1217 Meyrin-Geneva
Tel: (022) 41 54 00

CENTRAL AND SOUTH AMERICA

ARGENTINA
Buenos Aires

BRAZIL
★ Sao Paulo
Rio de Janeiro

MEXICO
★ Mexico City

VENEZUELA
Caracas

AFRICA, ASIA, AUSTRALIA

AUSTRALIA
★ Melbourne
Sydney
Adelaide
Perth, W.A.

JAPAN
Osaka
Nagoya
★ Tokyo

NEW ZEALAND
Wellington

SOUTH AFRICA
Cape Town
Johannesburg

FOR OTHER AREAS NOT LISTED CONTACT:

Hewlett-Packard Export Marketing
3200 Hillview Ave.
Palo Alto, California 94304, U.S.A.
Telex: 034-8461
Cable: HEWPACK Palo Alto

★ Identifies data center location.

For more information, call your local HP Sales Office or East (201) 265-5000 • Midwest (312) 677-0400 • South (404) 436-6181
West (213) 877-1282. Or, write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304. In Europe, 1217 Meyrin-Geneva, Switzerland