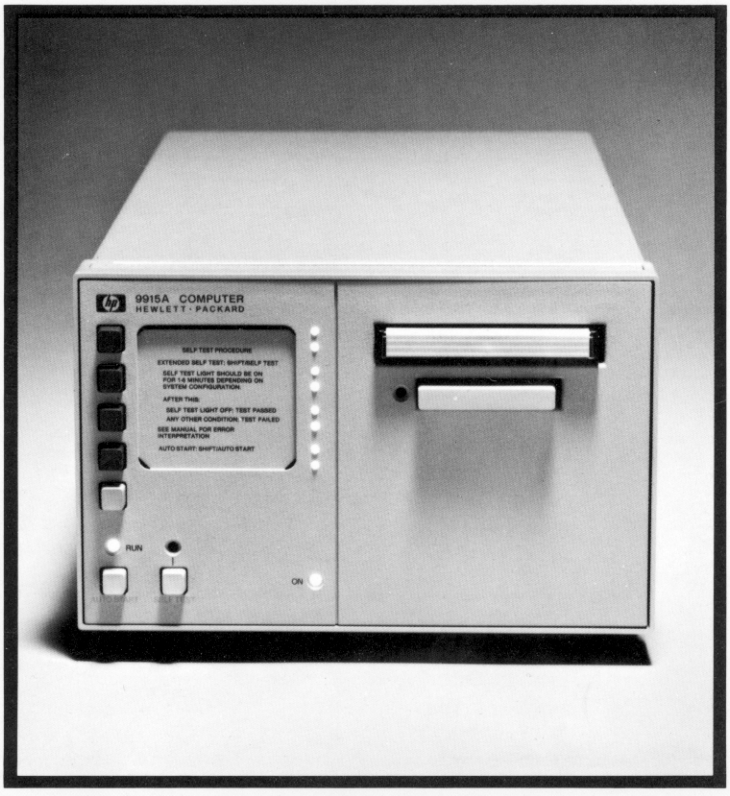
9915A

Modular Computer

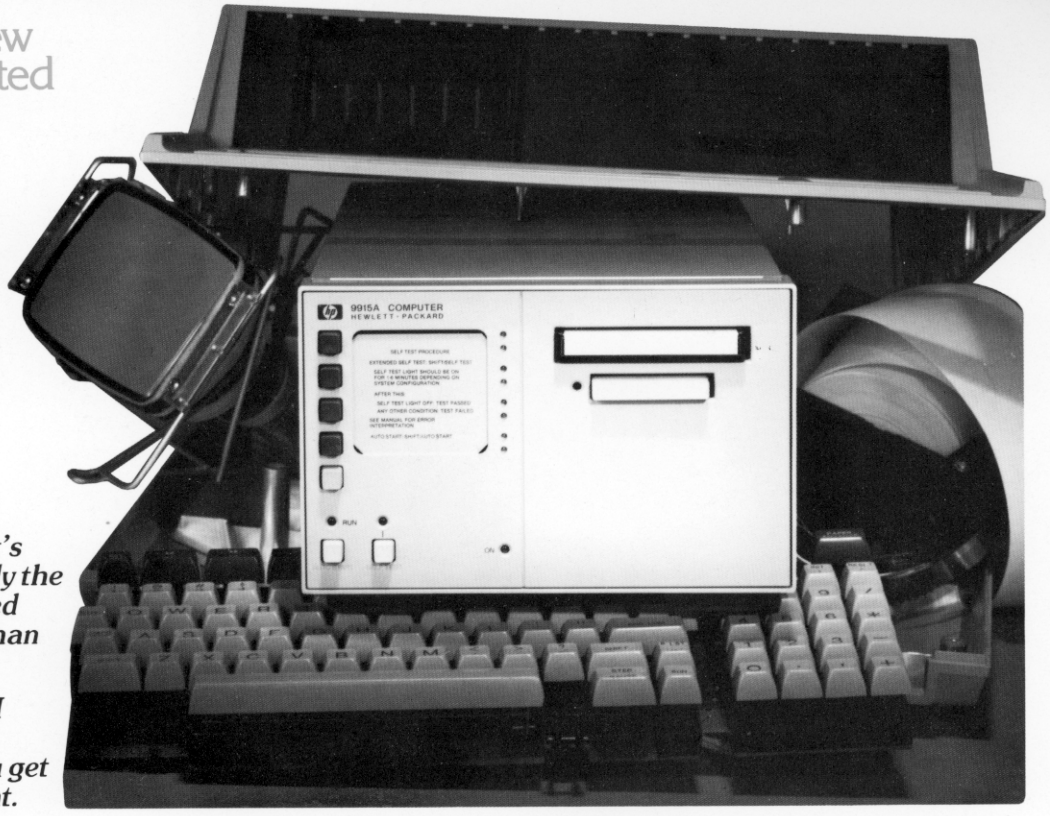


HEWLETT PACKARD

HP introduces a new concept in automated test, measurement and control:

the 9915A Modular Computer.

- ***It's FLEXIBLE and INEXPENSIVE because it's modular, so you get exactly the operator interface you need without paying for more than you want.***
- ***It's EASY TO PROGRAM because of its desktop computer heritage, so you get fast, low-cost development.***



The heart of an HP-85 Desktop Computer in a new, industrial package.

Automating a test or measurement system can be a complex and expensive task — but it doesn't have to be. The HP 9915A Modular Computer gives you the easiest and most cost-effective route to automation.

What is it?

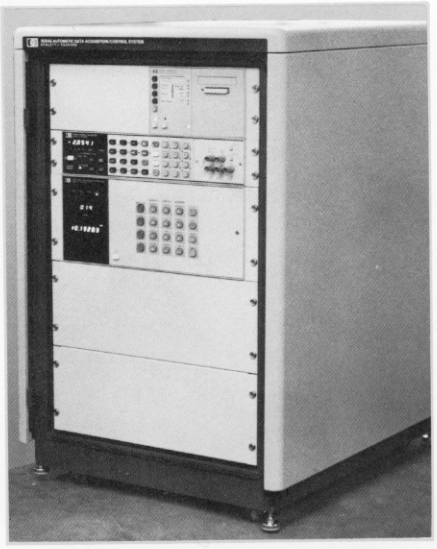
It's basically the heart of the HP-85 Desktop Computer in a modular package that makes it easy to integrate into a system. You can add most features you will ever need (keyboard, CRT, tape drive, peripherals) without having those features imposed on you. The 9915A is as flexible and inexpensive as a board computer, and as easy to program and interface as the desktop computer it sprang from. Designed for dedicated instrument control applications, the 9915A has the same powerful, flexible I/O capabilities as the HP-85, so it can easily direct your system's operation, gather data and analyze it.

Let's take a look at what this imaginative product is and where it fits in the spectrum of computer products available for instrument and measurement automation.

Instrument automation will never be the same.

It used to be that if you were automating test or measurement instruments, you had a limited number of product types to choose from. At one end of the spectrum were microprocessors and board computers that were inexpensive and quite flexible, but difficult to integrate, interface, program, debug and document. At the other end of the spectrum were powerful minicomputer systems with high costs for both hardware and development. In the middle were desktop computers. They offered ready-made interfacing and made program development easy with interactive operating systems and interpretive, high-level languages. But they were still relatively expensive if you were building multiple systems, because they included standard, general-purpose keyboards and displays that you had to pay for whether or not you needed them.

Now you have another alternative — the HP 9915A Modular Computer. The HP-85's central processor, memory, operating system and I/O ports have been packaged in a small, rack-mountable box, perfect for dedicated instrument control applications — a "desktop-in-a-box." From now on, you can have both fast, easy development and low cost. Instrument automation will never be the same.



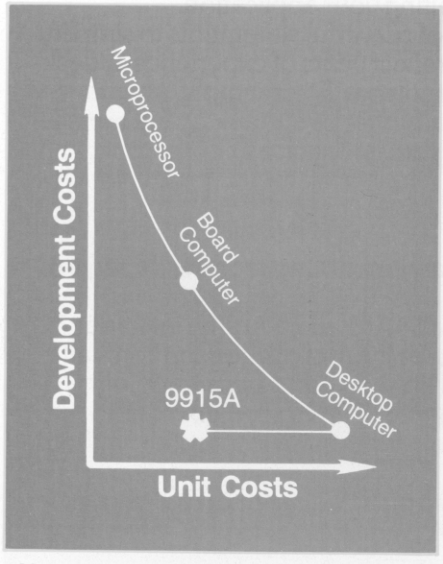
The 9915A's rugged, rack-mountable box and easy-interfacing design make it easy to integrate into an instrument system.

Cut your costs and development time in half.

Whether you're automating a line of measuring instruments, assembling measurement systems for the lab, or developing test systems for the production floor, the HP 9915A Modular Computer can increase your engineering effectiveness.

You can get your system running in half the time it would take for a microprocessor or a board computer, and pay far less for your development station, which is the HP-85 Desktop Computer. You get the benefits of a desktop computer for solving your automation problem, but if you don't need all the extras (full keyboard, CRT, printer), the 9915A solution will cost about half as much as an HP-85. If your application does require all the extras, and you don't need a custom keyboard or display, the HP-85 will be a more cost-effective solution.

In general, as you move from microprocessors to board computers and then to desktop computers, your development costs go down and the unit cost goes up. This is because more and more of your development work has been done for you by the computer manufacturer. But with the 9915A Modular Computer, you get the low development costs of a desktop computer AND the low unit cost of a board computer.



You no longer have to choose between low development costs and low hardware unit costs. The 9915A gives you both.

Typical development scenario:

1. Write your application programs on the HP-85 Desktop Computer. Plug in an I/O ROM (read-only memory) and 9915A Program Development ROM, and the HP-85 becomes an inexpensive development system. With the combination of a powerful, high-level language and an interactive operating system, you can have complete, debugged programs in a fraction of the time it would take using a lower level language. And you can use the HP-85 as a general-purpose desktop computer when you're through.

2. Do in-system software debugging using the HP-85. With the Program Development and I/O ROMs installed, the HP-85 can serve as a 9915A emulator. Just plug in the appropriate interface(s), connect them to your instrument(s), and use all the HP-85's interactive editing and debugging aids to find and correct any problems in your programs, quickly.

3. Transfer your application software to the 9915A via either EPROM (erasable programmable read-only memory) or magnetic tape, and plug in the interfaces. If you need the flexibility to change programs easily, you'll want the optional tape drive. For harsher industrial environments and for unalterable program storage, you can transfer your software from the HP-85 into EPROM, via a PROM programmer, and then install the EPROM in the 9915A.

If you need an external keyboard, display or other peripheral, you can connect them at this stage. The job is greatly simplified by the 9915's easy-interface design and extensive documentation.

4. Turn on the 9915A. That's all. The 9915A looks for a program named "Autost", first in EPROM and then on tape. It will automatically load and run the "Autost" program.

Your system is now running smoothly using hardware that costs about the same as a board computer, but it's running months sooner than would have been possible with a board computer, and you've saved at least half on your development costs.

The HP-85 Desktop Computer is an inexpensive, easy-to-use, development station and emulator for the 9915A.

Fast, inexpensive development and

flexible interfacing

An external display and/or keyboard can be located wherever convenient.

Custom operator interfaces

The 9915A Modular Computer is designed to provide a low-cost solution for dedicated test and measurement applications requiring minimal or custom operator interfaces. If user controls can be simplified, operator errors can be minimized. For many applications, the eight Special Function Keys and eight LEDs on the front panel will provide all the operator interface required.

However, if your application requires more extensive operator controls or a display, you can easily add remote pushbuttons and/or LEDs, numeric keypad, typewriter keyboard, custom keyboard, large or small CRT monitor, or peripherals. We've designed the interfaces and written the I/O drivers for you. The technical information you need for easy installation is included in the 9915A System Development Manual.

Because all the HP-85's sophisticated graphics capabilities are included in the 9915A, you can make information more meaningful to an operator by displaying charts, graphs, histograms, block diagrams or other graphics on an external CRT. The graphics can be continuously updated to reflect current conditions.

I/O-oriented language

The HP-85/9915 extended version of BASIC retains the friendliness of ANSI BASIC while adding many powerful features from other languages. In fact, this version of BASIC has several times as many statements, commands and predefined functions as ANSI Minimal BASIC. It will help you slash your development time without limiting your application.

HP-85/9915A BASIC includes a set of powerful statements to simplify I/O. These I/O language enhancements reflect years of experience in desktop computer interfacing and instrument control. For example, after a program does an initial setup of the instruments in a system, a data transfer can be initiated with a single, simple program line such as:

```
TRANSFER Z$ TO 6 INTR
```

To accomplish the same thing using assembly language would require many lines of code.

The 9915A and its BASIC language also provide you with interrupt, bit manipulation, high-speed transfer, software control of interface configuration and easy data formatting. With the TIMEOUT and error trapping features, you can write subroutines to handle various problem conditions automatically. Thus unattended operation can continue smoothly without waiting for operator intervention.

The language can be further extended by three optional ROMs (read-only memories): the Plotter/Printer ROM, the Mass Storage ROM for flexible discs and the Matrix ROM.

The complete vocabulary of the 9915A's BASIC is listed in the specifications section.

Powerful, extended BASIC, *compatible with HP-85, for fast program development.*

Advanced I/O language *for easy data acquisition and instrument control.*

Tab slot for custom labeling *of LEDs and Special Function Keys.*

Eight software-definable special functions *(four shiftable keys) for simple operator control of a running program.*

AUTOSTART *for completely automatic operation at power on or after power interruption.*

Extensive SELF TEST *to assure proper operation before running application programs, and to speed up repair.*

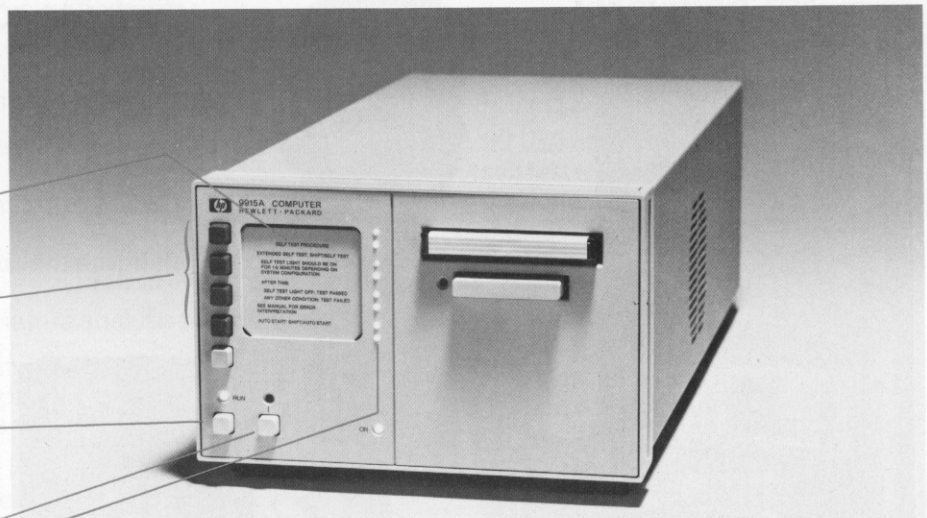
Eight LEDs *for simple, dedicated feedback to operator.*

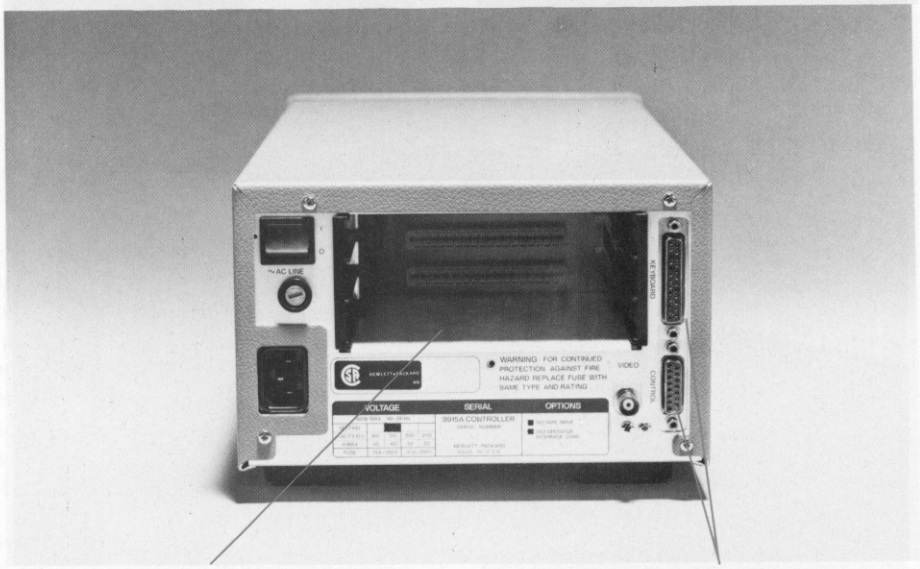
Optional cartridge tape drive *for data storage and for the flexibility to revise or replace application programs easily.*

16K or 32K bytes of read/write memory, *all available for your application programs and data.*

EPROM storage *of application programs for industrial environments, tamper-free storage and fast loading.*

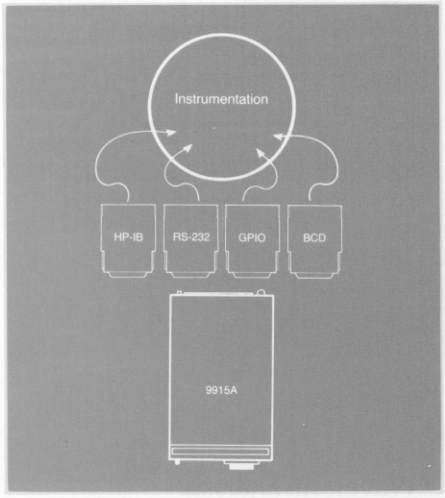
Ready-made interfaces *for HP-IB, GPIO, RS-232 and BCD, providing easy communication with a wide variety of instruments and peripherals.*





Two or three I/O slots, *depending on memory size, for multiple instrument systems and/or peripherals.*

Easy interfacing to external keyboard, CRT and LEDs *so you can customize the operator interface.*



Plug-in interfaces and built-in I/O drivers simplify interfacing to instruments.

Ready-made instrumentation interfaces

The 9915A is easy to interface to measuring instruments. It uses the same plug-in interfaces as the HP-85 Desktop Computer:

- HP-IB (IEEE 488-1978)
- Serial (RS-232-C)
- GPIO (8-bit or 16-bit parallel)
- BCD (Binary Coded Decimal)

These four cards allow the 9915A to communicate with a nearly endless variety of instruments. Because the I/O drivers have been written for you and are built into the 9915A, all you have to do is plug in the interface card and connect the other end to the instrument. You save months of designing your own interfaces and writing and debugging I/O drivers.

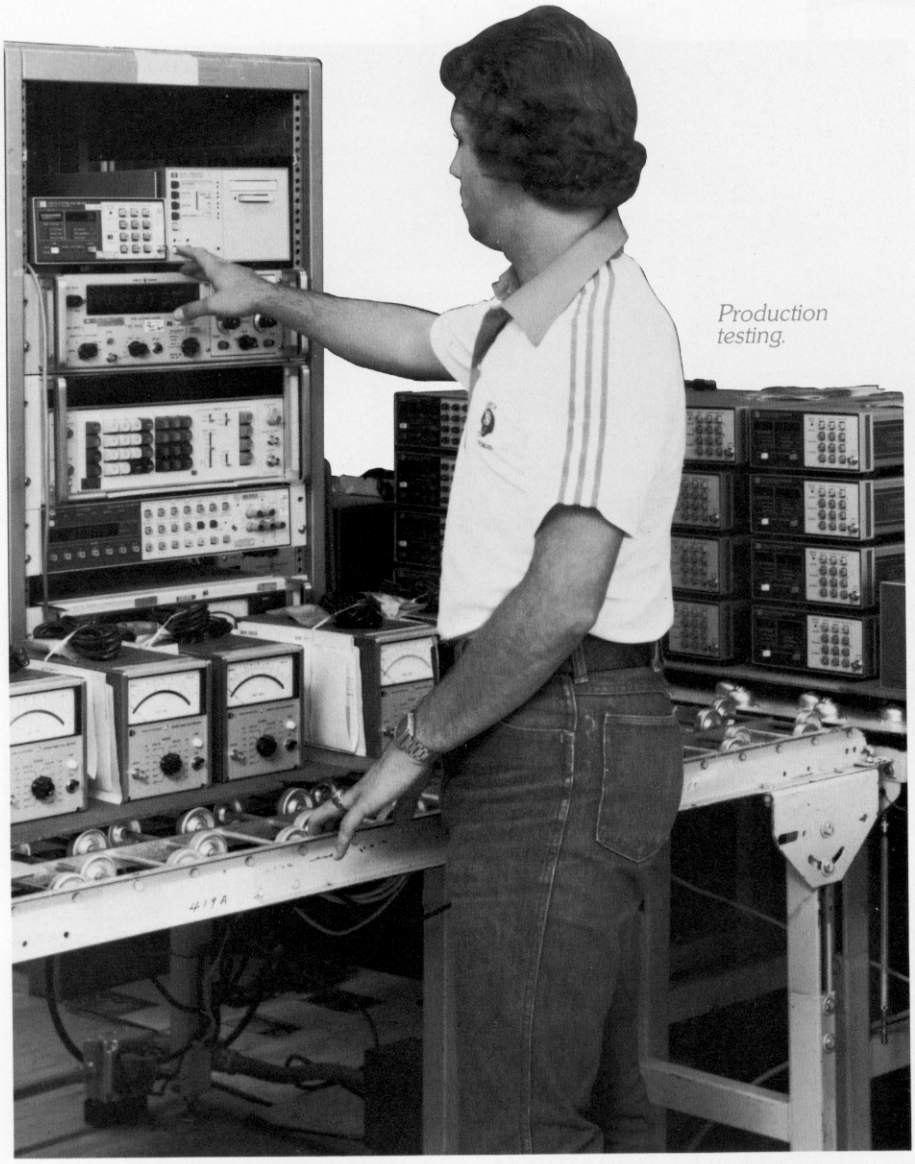
Plug-in peripherals

A complete line of peripherals is available for the 9915A. Included are printers, plotters and flexible disc drives. If you need to interface to analog devices, HP multiprogrammers (card cages) are available with cards for such functions as analog input and output, digital input and output, stepper motor control, timing and counting.

A reliable solution for

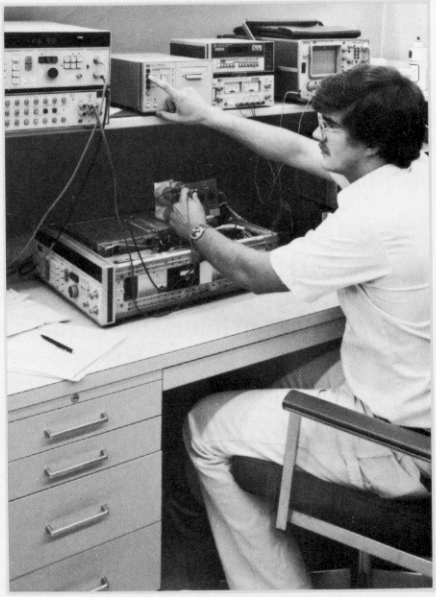
innumerable applications

Save time and money when automating these and others.



Production testing.

- Amplifier testing
- Appliance testing
- Atomic absorption analysis
- Battery testing
- Biological research
- Blood gas analysis
- Brake dynamometer testing
- Clinical blood-ion testing
- Color densitometry
- Coordinate measuring
- Disc drive testing
- Elastic fiber testing
- Electronic filter testing
- Electronic weighing
- Energy conservation research
- Energy management
- Environmental monitoring
- Environmental testing
- Fiber thickness testing
- Flow meter production testing
- Fluid particle counting
- Geo-thermal searches



Research and development.

- Incoming inspection of electronic components
- Inertia measurement
- Integrated circuit testing
- Ionized calcium analysis
- Ion microanalysis
- Laser life testing
- Mass spectrometry
- Mechanical material testing
- Meterology instrumentation
- Micro positioning
- Microwave diode testing
- Microwave link testing
- Multimeter testing
- Network analysis
- Optical fiber manufacturing
- Optical lens grinding
- Optical radiation measurement
- Pacemaker testing
- Precision displacement measurement
- Precision motion measurement
- Pressure measurement
- Printed circuit board testing
- Radioimmunoassay
- Radio receiver production testing
- Relay testing
- RFI and EMI testing
- Spectrofluorometry
- Spectrophotometry
- Spectroradiometry
- Spectrum analysis
- Telecommunications testing
- Telephone component testing
- Television testing
- Tensile strength testing
- Thin-film measurement
- Transformer testing
- Transistor testing
- Traveling wave tube testing
- Ultrasonic thickness measurement
- Urine analysis
- Vibration analysis
- Water analysis
- Waveform analysis
- Well logging

Engineered for reliability

Hewlett-Packard has a 40-year reputation for quality and reliability, and in the 9915A we have set new standards of excellence in areas such as:

- Immunity to line transients, electrostatic discharge, and electric and magnetic fields.
- Cooling (Internal temperature rise limited to 7°C at the most susceptible locations).
- Mechanical interconnects (minimized with proprietary LSI and product partitioning).
- Testability (with SELF TEST and signature analysis techniques).

Careful attention was given to identifying potential problems and improving the design before beginning production. We drew upon information gained from the successes and failures experienced during:

- Environmental testing: temperature, humidity, shock and vibration.
- Radiated and conducted interference testing.
- Abuse testing: temperature extremes, rough handling and UL qualification.
- Susceptibility testing: electrostatic discharge to 15 kV, electric fields to 10 V/m and line transients to 1 kV.

This aggressive testing program was driven by HP's "test-fix-test" philosophy. David Packard put it this way: "There is only one road to reliability. Build it, test it, and fix the things that go wrong. Repeat this process until the desired reliability is achieved. It is a feedback process and there is no other way."

The final proof of product quality is found in the production environment and is determined by its parts, processes and people. HP's experienced production staff worked closely with vendors to establish and maintain incoming quality levels. Automated PC board loading and circuit testing assure product consistency. Temperature cycle testing is used as a process monitor and early warning system to maintain reliability goals.

Binding together the production process are its people, working together in units known as quality circles. These groups draw on the combined knowledge and experience of their people to maintain and improve the production process.

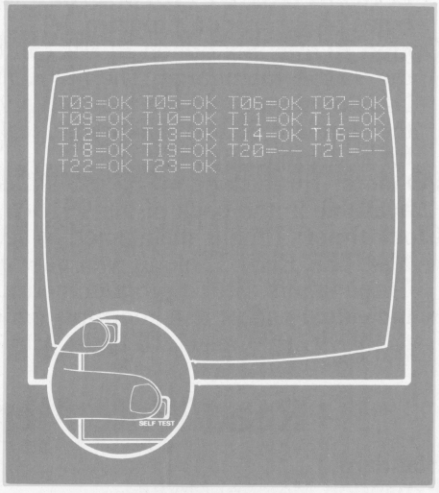
These are just a few of the reasons engineers and scientists all over the world consider Hewlett-Packard equipment to be among the most reliable on the market. Make our reliability part of your system.

Quality assurance testing.

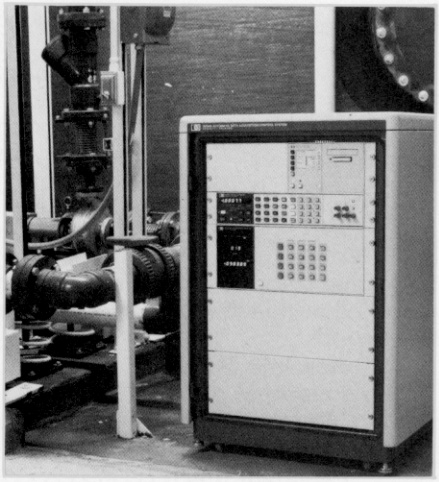
Designed for easy servicing

Every time you turn on a 9915A, it automatically performs a self test to assure you it is in good working order. If a problem is indicated, just press the shift key and the SELF TEST button, and the 9915A will perform a more exhaustive series of tests and indicate, by number, the results of each test. You and the service person will both know right where the problem is. With built in SELF TEST and signature analysis, repairs are quick and easy.

We've made a large investment in service so you won't have to. Hundreds of thoroughly trained HP service engineers all over the world stand ready to service the 9915A Modular Computer.



A thorough SELF TEST helps locate any problems quickly.



Facility Management

General Information

Features

Front Panel Keys:
- Eight Special Function Keys (four shiftable keys).
- AUTOSTART key to load and execute "Autost" file.
- SELF TEST key to initiate self test.
- All keys can be disabled by appropriate program statements.

Lights:
- Eight LEDs (four green and four yellow) to annunciate label area.
- RUN to indicate running BASIC program.
- SELF TEST to indicate self test mode.
- ON to indicate power applied.
- Tape access LED.

Label area: 55 mm (2.28 in.) by 53.5 mm (2.11 in.) area where a plastic insert can be installed to label the Special Function Keys and LEDs.

EPROM card: A socketed PC board allowing eight EPROMs (2516, 2716, or 2732) to store up to 32K bytes of application program.

Option ROMs: Six option ROMs can be installed inside the 9915A mainframe. The I/O ROM and the Program Development ROM are required and are included in the standard 9915A mainframe, leaving four openings for additional option ROMs.

I/O slots: Three standard HP-85 I/O card slots are available in the back of the 9915A.

Clock/timer: Time is maintained as seconds since MASTER RESET, along with year and day in year. Three timers can be programmed to generate individual end of line interrupts periodically, at intervals to 99 999 999 ms (1.16 days) with 1 ms resolution.

Read/Write Memory

Standard	16K bytes
Expansion Memory Module	16K bytes

Dynamic Range

Real Precision:	−9.99999999999E499 to −1E−499,0, and 1E−499 to 9.99999999999E499
Short Precision:	−9.9999E99 to −1E−99,0, and 1E−99 to 9.9999E99
Integer Precision:	−99999 to 99999

Built-in Functions

Mathematical and trigonometric functions are included in the following table with average execution times in milliseconds.

Absolute (ABS)	0.83
Fractional part (FP)	1.01
Integer part (IP)	2.56
Maximum (MAX)	6.42
Minimum (MIN)	6.19
Modulus (MOD)	2.21
ln (LOG)	32.11
log (LGT)	26.63
e^x (EXP)	24.54
Raise to power (Y^X)	43.92
Random number (RND)	3.54
Sign (SNG)	0.90
Square root (SQR)	8.74
Sine (SIN)	45.62
Cosine (COS)	45.69
Tangent (TAN)	27.27
Arcsine (ASN)	43.23
Arccosine (ACS)	43.98
Arctangent (ATN)	22.76
Cosecant (CSC)	51.68
Secant (SEC)	51.72
Cotangent (COT)	27.29
+	1.08
−	1.12
/	5.92
*	2.85
Ceiling (CEIL)	2.91
Floor (FLOOR)	3.33

Built-in operators
Logic: AND, OR, NOT, EXOR
Relational: =, 〈, 〉, 〈=, 〉=, 〈〉 (or #)

Environmental Range

Operating temperature:	0°C to 55°C
Humidity:	95% R.H., 0°C to 40°C
Storage temperature:	−40°C to 75°C
EMI:	9915A conducted and radiated interference is within the requirements of VDE 0871 and CISPR publication 11.

Size and Weight

Height	145 mm (5.71 in.)
Width	213 mm (8.39 in.)
Depth	446 mm (17.56 in.)
Cube	0.014 cubic m (0.49 cubic ft)
Net Weight	4.54 kg (10.0 lb)
Shipping Weight:	
Std	7.54 kg (16.6 lb)
w/Opt. 001	7.90 kg (17.4 lb)
w/Opt. 002	7.67 kg (16.9 lb)
w/Opt. 001 & 002	8.03 kg (17.7 lb)

Power Requirements

Source	100, 120, 220, 240 V ac ±10%. Voltage is switch selectable.
Line frequency	48 − 66 Hz
Consumption	0.45 A @ 100 V 0.40 A @ 120 V 0.22 A @ 220 V 0.20 A @ 240 V

Options

Tape Cartridge (Opt. 001)

Capacity:	
Data	210K bytes
Programs	195K bytes
File management	by name, up to 42 files
Read/Write speed	254 mm/s (10 in./s)
Search speed	1524 mm/s (60 in./s)
Average transfer rate	650 bytes/s
Rewind time	29s end to end

Tape length	43 m (140 ft)
Cartridge size	61.2 × 80.9 × 11.9 mm (2.41 × 3.18 × 0.47 in.)
Security	programmable and mechanical switch
Environmental:	(Restricted due to magnetic tape characteristics)
Operating temperature	0°C to 40°C
Relative humidity	(non-condensing; 30°C max wet bulb) 20% to 80% R. H.
Storage temperature	−40°C to 60°C

NOTE: Tape cartridges are intended for nominal program or data storage; the typical life cycle is 50 to 100 hours of use, depending on the application. Environmental conditions of 25°C (77°F) and 20 to 50% relative humidity are most favorable for a long tape life. Tape life is decreased by a high duty cycle (percent of time the tape is accessed during the total time the 9915A is in use) and continuous use for long periods of time (longer than one-half hour). It is suggested that tape transports be cleaned regularly and cartridges removed from drives after use.

Operator Interface (Opt. 002)

Video Interface

Composite video	(Similar to EIA RS 170)
Connector	BNC, 50 ohm, female, straight receptacle body
Cable length, max.	30 m for RG58U coax (50 ohm)
Lines/Frame	262, non-interlaced
Frame rate	60 Hz
Horizontal frequency	15720 Hz
Visible lines	192

Nominal electrical output levels:

Output impedance	75 ohm
Sync reference level	0.35 V
Blanking level	0.7 V
White reference level	1.7 V

External CRT display features:

Alphanumeric text	16 lines × 32 characters
Alphanumeric scrolling	64 lines (16 visible on screen)
Character set	256 characters; set of 128 & same set underscored
Character font	5 × 7 dot matrix in an 8 × 12 dot cell
Cursor	underline
Graphics	192 × 256 dots (vert./horiz.)

NOTE: An adjustment of the monitor's vertical height and horizontal width may be required to correct the graphics aspect ratio.

Keyboard and speaker interface:

Connector – 25 pin D-subminiature connector, female pin and straight plug body.
Cable length – 30 m, 4000 pF capacitance maximum as measured on any row or column connector pin.
Keyboard matrix – 8 rows × 10 columns, buffered and debounced, providing 76 implemented cross points. The shift, control, and caps lock keys are provided with dedicated lines.
Speaker signal – Unipolar output, 100 ma ±20% into an 8 ohm load.
Grounding – Separate signal ground and cable shield ground are provided.
External source – when applied to pins, source must be current limited to 25 mA.

Control signals interface:

Connector – 15 pin D-subminiature connector, female pin and straight plug body.
Cable length – 30 m, maximum load of 4000 pF capacitance as measured at any output pin.
Grounding – Separate signal ground and cable shield ground are provided.
Annunciator signals – Output lines, eight lines logically parallel to the front panel annunciators.
Run signal – Output, active high, logically parallel to the front panel RUN light.
SELF TEST signal – Output, active high, logically parallel to the front panel SELF TEST light.
Master reset signal – Output, active low when:
- Power off,
- 9915A detects brown out,
- AUTOSTART executed from front panel, software, or operator interface input,
- SELF TEST asserted from front panel or operator interface.

AUTOSTART initiate – Input, active low, logically parallel to the front panel AUTOSTART key, buffered and debounced; a system master reset is initiated upon asserting a low input and autostart is initiated upon release of the asserted low input.
SELF TEST initiate – Input, active low, logically parallel to the front panel SELF TEST key, buffered and debounced; a system master reset is initiated upon asserting a low input and self test is initiated upon release of the asserted low input.
Nominal electrical levels:
V_{ol} (outputs only): load = 1 LSTTL input; during power off states, the output maintains a low impedance.
V_{oh} (outputs only): load = 1 LSTTL input.
V_{oc} (outputs only): Open circuit voltage = 3.5V.
I_{os} (outputs only): Short circuit output current 90 mA max.
V_{ih} (inputs only): Internal pullup for high logic level.
V_{il} (inputs only): 0.4V @ $I_{il} < -6$ mA, asserted low logic level.
External source – when applied to pins, source must be current limited to 25 mA.

BASIC Language Syntax

System Functions

ABS – returns absolute value of the numeric expression.
ACS – returns the principal value (1st or 2nd quadrant) of the arccosine of the numeric expression in the current angular units.
ASN – returns the principal value (1st or 4th quadrant) of the arcsine of the numeric expression in the current angular units.
ATN – returns the principal value (1st or 4th quadrant) of the arctangent of the numeric expression in the current angular units.
ATN2 – returns the arctangent of Y/X in proper quadrant.
CEIL – returns the smallest integer greater than or equal to the numeric expression.
COS – returns the cosine of the angle represented by the numeric expression.
COT – returns the cotangent of the angle represented by the numeric expression.
CSC – returns the cosecant of the angle represented by the numeric expression.
DATE – returns the Julian date in the format YYDDD, assuming system timer was set.
DTR – converts the value of the numeric expression from degrees to radians.
EPS – returns a constant equal to the smallest positive real precision number, 1E-499.
ERRL – returns the line number in which the last error occurred.
ERRN – returns the error number of the last error.
EXP – returns the value of Napierian e raised to the power of the computed expression.
FLOOR – returns the largest integer less than or equal to the evaluated expression.
FP – returns the fractional part of the evaluated expression.
INF – a constant equal to the largest real number possible, 9.99999999999E499.
INT – returns the largest integer less than or equal to the evaluated expression (equivalent to FLOOR).
IP – returns the integer part of the numeric expression.
LGT – returns the common logarithm (base 10) of a positive numeric expression.
LOG – returns the natural logarithm (base e) of a positive numeric expression.
MAX – returns the larger of two values.
MIN – returns the smaller of two values.
PI – returns the value of pi (#).
RMD – returns the remainder resulting from a division operation according to X–(Y*IP(X/Y)).
RND – generates a number that is greater than or equal to zero and less than one, using a predetermined, pseudo-random sequence.
RTD – converts the value of the numeric expression from radians to degrees.
SEC – returns the secant of the angle represented by the numeric expression.
SGN – returns a 1 if the expression is positive, –1 if negative and 0 if exactly 0.
SIN – returns the sine of the angle represented by the numeric expression.
SQR – returns the square root of a positive numeric expression.
TAN – returns the tangent of the angle represented by the numeric expression.
TIME – returns the time in seconds since midnight if the timer is set, or since machine turn-on otherwise, resetting automatically after 24 hours.

String Functions

CHR$ – converts a numeric value between 0 and 255 into a character corresponding to that value.
LEN – returns the number of characters in a string.
NUM – returns the decimal value corresponding to the first character of the string expression.
POS – returns the position of the first character of a substring within another string or 0 if the substring is not found.
UPC$ – converts all lowercase letters in a string to uppercase letters.
VAL – returns as a numeric value, including exponent, a string of digits so that the value may be used in calculations.
VAL$ – returns the value of a numeric expression as a string of digits.

General Statements

BEEP – outputs a tone of specified frequency for a specified duration via operator interface (Opt. 002).
CLEAR – clears the CRT.
COM – dimensions and reserves memory so chained programs can access the same data.
CRT IS – allows the definition of the select code of the current CRT.
DATA – provides constants and text characters for use with READ statements.
DEFAULT ON – makes numeric overflows, underflows and the use of uninitialized variables non-fatal by substituting an appropriate approximate value.
DEFAULT OFF – makes numeric overflows, underflows and the use of uninitialized variables fatal.
DEF FN – defines a single or multiple-line function.
DEG – sets degree mode for evaluation and output of the arguments and results of trigonometric functions.
DIM – declares the size and dimensions of array and string variables.
DISP – outputs the values or text via operator interface (Opt. 002) or to the current CRT.
DISP USING – displays values and text according to format specified by IMAGE statement or literal IMAGE.
END – terminates program execution (same as STOP).
FLIP – changes the keyboard from BASIC mode to typewriter mode or vice versa.
FN END – terminates a multiple-line function.
FOR/NEXT – defines a program loop and the number of iterations.
GOSUB – transfers program control to a subroutine and allows subsequent return of control.
GOTO – transfers program execution to the specified line.
GRAD – sets grad mode for evaluation and output of the arguments and results of trigonometric functions.
IF...THEN...ELSE – allows statements to be either executed or bypassed depending on the outcome of a logical expression.
IMAGE – specifies the format used with PRINT USING or DISP USING statements.
INPUT – allows entry of values or text from the keyboard during program execution.
INTEGER – declares variables as integers as well as the size and dimensions of integer arrays.
KEY LABEL – displays in the lower portion of the CRT, an eight-character prompt for each Special Function Key defined by an ON KEY statement. Also returns cursor to upper left corner of the CRT.

LET – assigns a value to a variable or array element.
LIST – lists the program on the CRT, filling one screen each time it is executed. Also outputs bytes remaining at the end of a program.
NORMAL – cancels the effect of the PRINT ALL, AUTO or TRACE statements.
ON ERROR – sets up a branch to the specified line or subroutine anytime an error occurs.
OFF ERROR – cancels any ON ERROR statement previously executed.
ON KEY # – sets up a branch to the specified line or subroutine each time the Special Function Key is pressed.
OFF KEY # – cancels the branch set up by an ON KEY # statement.
ON TIMER # – sets up a branch to the specified line or subroutine on a time-dependent interrupt basis.
OFF TIMER # – cancels any interrupts from a timer set up by an ON TIMER # statement.
OPTION BASE – allows specifying the lower bound of an array as 1 rather than the default of 0.
PAUSE – suspends program execution.
PLIST – lists the program on the printer defined by PRINTER IS.
PRINT – used to print values or text on the current printer.
PRINT ALL – sets a mode such that all inputs, messages and results are printed on the printer defined by PRINTER IS.
PRINT USING – prints values and text according to format specified by an IMAGE statement or literal IMAGE.
PRINTER IS – allows the definition of the select code to be used as "printer".
RAD – sets radian mode for evaluation and output of the arguments and results of trigonometric functions.
RANDOMIZE – re-evaluates the random number seed.
READ – assigns values from a DATA statement to the variables specified.
REAL – declares full-precision variables as well as the size and dimensions of full-precision arrays.
REM – declares the subsequent characters as remarks for documentation only.
RESTORE – resets data pointer to the start of the specified DATA statement, or the first DATA statement if none is specified.
RETURN – transfers program control back to the statement following a GOSUB.
SHORT – declares variables as being short-precision as well as the size and dimensions of short-precision arrays.
STOP – suspends program execution (same as END).
TAB – used in a DISP or PRINT statement to allow information to be placed at a specified character position.
TRACE – traces program logic flow in all or part of a program as specified and prints this information.
TRACE ALL – traces all program logic flow and variable assignments in all or part of a program as specified and prints this information.
TRACE VAR – traces all value changes of specified variables and prints this information.
SETTIME – sets the system clock with the parameters of seconds since midnight and Julian day in form YYDDD.
WAIT – holds program execution for the specified number of milliseconds.

Mass Storage Statements

(With Option 001 Tape Drive)

ASSIGN# – opens a data file by assigning a buffer number to it.
CAT – displays a file directory on the CRT screen.
CHAIN – loads a new program from tape and continues executing while retaining any data in common.
CREATE – establishes a data file of specified length and record length on mass storage devices.
CTAPE – conditions the tape by running it to end, then rewinding it to assure smooth operation of the entire tape.
ERASETAPE – initializes a tape by creating a blank directory.
LOAD – brings into memory a program previously stored on a mass storage device.*
LOAD BIN – brings a binary program into memory.
PRINT # – records data onto the referenced file.
PURGE – erases the specified file from the tape directory, rendering it inaccessible.
READ # – retrieves values from a specified file.
RENAME – changes the name of an existing file.
REWIND – rewinds the tape to its beginning point.
SECURE – prevents unauthorized listing, editing, duplicating or cataloging of a program.
STORE – records a program onto the mass storage device.*
STORE BIN – records a binary program onto the mass storage device.
UNSECURE – allows files previously secured to be listed, edited, duplicated and cataloged.*

Graphics Statements

(Using Option 002 Operator Interface and External CRT)

ALPHA – puts the CRT into its alphanumeric mode.
BPLOT – allows plotting any series of dots on the CRT by conversion to an alphanumeric string.
DRAW – lowers the pen and draws a line from current pen position to a specified destination position.
GCLEAR – clears all or a specified lower section of the graphics display.
IDRAW – lowers the pen and draws a line of specified incremental length from the present position.
IMOVE – lifts the pen and moves the pen an incremental distance from the present position.
LABEL – allows printing of text in the graphics mode.
LDIR – specifies horizontal or vertical direction of a label.
MOVE – lifts the pen and moves the cursor to a specified absolute location.
PEN – sets a positive or negative pen number.
PEN UP – raises the "pen" so that plotting is possible without drawing lines between points.
PLOT – moves to a specific point if pen is up; draws a line to the point if pen is down.
SCALE – defines the incremental units and range of x and y on the CRT.
XAXIS – draws a horizontal line of specified length, with or without tick marks, at a specified y intercept.
YAXIS – draws a vertical line of specified length, with or without tick marks, at a specified x intercept.

Non-Programmable Commands

AUTO – allows automatic generation of line numbers during program entry.
CONT – allows continuation of a program which has been paused.
DELETE – deletes program lines specified.
INIT – initializes a program by allocating memory for the variables required, and performs a check for certain errors.
REN – renumbers program lines with specified increments.
RUN – initializes a program and begins its execution.
SCRATCH – clears memory of all programs and data.

* Not programmable.

ROMs (read-only memories)

Three optional ROMs are available for the 9915: the Plotter/Printer ROM, the Mass Storage ROM and the Matrix ROM. For information on these, please see the Configuration Guide inside the back cover.

Two standard ROMs are part of the 9915A: the Program Development ROM and the I/O ROM. Their descriptions follow.

Program Development ROM

The Program Development ROM (Part No. 98151A) provides capability in two operating environments.

In the 9915A, the ROM supports the product features of EPROM program storage, front panel LEDs, the control keys (AUTOSTART and SELF TEST) and the built-in self test. The ROM also enhances the control of external CRT monitors and keyboards.

In the HP-85 program development system, the ROM supports all of the 9915A product features not available in the standard HP-85 (EPROM emulation, front panel LED emulation) and provides enhancements to CRT and keyboard control.

Specifications

ROM Memory – adds 8K bytes of read-only memory to the operating system.
R/W Memory – uses 171 bytes of user read/write memory.

ROM Statements

EPROM Program Storage

PLOADBIN – loads the specified binary program from user PROM.
PCHAIN – loads the specified file from user PROM and runs the program. Saves variables declared in COMMON memory and binary program currently in memory.
PLOADGO – scratches memory and loads and runs the program specified from user PROM.
AUTOSTART – executes power on sequence of self test followed by loading and running program named "Autost" from user PROM. If this program is not found, the optional tape is searched. If not found in either location, an error results.
PROM IS – allows redirection of PLOADBIN, PCHAIN, PLOADGO statements during program development. May also be used for program downloading.
CHECKSUM$ – returns the 16-bit cyclic redundancy check code (CRCC) of the string specified. Useful in program download applications.

Front Panel Control

SLITE – provides control and status checking of the eight programmable front panel LEDs.
ENABLE AS-ST – enables or disables the AUTOSTART and SELF TEST keys on the front panel.

Keyboard Control

ON KBD – enables an end of line branch when any key is pressed.
OFF KBD – cancels the condition established by ON KBD.
KBD$ – this function returns a string expression containing keystrokes captured by ON KBD.
KBD CONVERT – converts the characters received from the keyboard via KBD$.
FIND – returns the character position of the first character which has the most significant bit set. Allows searching for "system" keystrokes in KBD$.
KEYDOWN – returns the numeric value of the key currently being held down. Used to implement key repeats when a key is held down.

CRT Display Control

CCLEAR – clears the contents of the CRT memory and positions the cursor to the start of display memory.
CCURSOR – moves the cursor to the requested character position.
CLINE – positions the start of the display window to the specified line number.
CCPOS – returns the numeric value that indicates the current cursor position.
CLPOS – returns the line number of the first line of the display window.
CCHR$ – returns a specified number of characters from the CRT memory starting with a specified location.
CWRITE – outputs a sequence of characters to the display memory starting at the current cursor position, printing control characters and leaving the cursor "blank."
CDISP – displays a sequence of characters starting at the current cursor position. The cursor is displayed. Control characters are interpreted to allow line feed, backspace, etc.
CPRINT – functions with the HP-85 printer in the same manner as CDISP.
ON CCODE – allows branching on control codes not implemented in CDISP or CPRINT.
OFF CCODE – turns off branching on control codes in CDISP and CPRINT.

I/O ROM

The I/O ROM (Part No. 00085-15003) provides basic input and output capabilities including formatted, free-field, and binary ENTERs and OUTPUTs with or without character conversions. The ROM also has card status and control capabilities, interrupt and fast handshake data transfers, HP-IB control, handshake timeouts, and card interrupt control. Other features include bit manipulation, base conversion, keyboard masking and error determination.

Specifications

ROM memory – adds 8192 bytes of read-only memory to the operating system.
R/W memory – uses 416 bytes of read/write memory out of the available user memory.
Speeds – fast handshake up to 26K bytes/second (maximum data rate – actual rates depend on the program, I/O card and peripheral used).

General Statements

The I/O ROM adds a set of general capabilities to the 9915A that do not deal with interfacing. These capabilities provide for bit manipulation, base conversion, keyboard masking, and error determination.

BINAND – returns the logical AND of two 16-bit values.
BINCMP – returns the binary complement of a 16-bit value.
BINEOR – returns the logical EXCLUSIVE OR of two 16-bit values.
BINIOR – returns the logical INCLUSIVE OR of two 16-bit values.
BIT – returns the value of a specified bit.
BTD – returns the decimal value of a binary string.
DTB$ – returns a string with a binary representation of a decimal number.
DTH$ – returns a string with a hexadecimal representation of a decimal number.
DTO$ – returns a string with an octal representation of a decimal number.
ENABLE KBD – allows disabling and enabling sections of the keyboard to prevent unintentional keystrokes.
ERRSC – returns the select code of the last card that caused an error.
ERROM – returns the ROM number of the last option ROM that caused an error.
HTD – returns the decimal value of a hexadecimal string.
OTD – returns the decimal value of an octal string.

Universal I/O Statements

The I/O ROM adds a set of interfacing capabilities to the 9915A which are common to all interfaces. These capabilities provide for data transfers, data conversions, interface control, interrupts and end-of-line branching.

CONTROL – allows access to I/O card control registers or I/O buffer control registers.
CONVERT – sets up input or output conversion tables for ENTER or OUTPUT on a specified select code or an I/O buffer. The conversion can be an indexed table or a pairs lookup table.
ENABLE INTR – sets up an I/O card to interrupt on a specified condition.
ENTER – allows for formatted or free-field entry of data from an I/O card or an I/O buffer.
IOBUFFER – converts a string variable into an I/O buffer.
OFF EOT – turns off the end of transfer end-of-line branch.
OFF INTR – turns off the ENABLE INTR end-of-line branch.
OFF TIMEOUT – turns off the SET TIMEOUT end-of-line branch.
ON EOT – specifies where to go in the BASIC program on end of transfer.
ON INTR – specifies where to go in the BASIC program when an event interrupt is received.
ON TIMEOUT – specifies where to go in the BASIC program when a handshake timeout occurs.
OUTPUT – allows for formatted or free-field output of data to an I/O card or to an I/O buffer.
RESET – causes a hardware reset of the I/O card.
SET TIMEOUT – causes handshakes to an I/O card to be timed, and when the specified length of time has passed, an end-of-line branch is taken to the ON TIMEOUT service routine.
STATUS – allows access to I/O card status registers or I/O buffer status registers.
TRANSFER – allows for fast handshake (FHS) or interrupt data transfers between an I/O buffer and an I/O card.

Interfaces

HP-IB Interface

The HP 82937A Interface implements the IEEE 488-1978 Standard Digital Interface for Programmable Instrumentation. The interface can communicate with as many as 14 HP-IB compatible instruments, with a total of no more than 20 metres of cable. The HP 82937A uses an interface processor to provide efficient management of the interface bus protocol, and can achieve data transfer rates of up to 26K bytes/second (absolute maximum).

Data Input/Output

Eight bi-directional data lines provide data input/output.

Control Lines

DAV, NRFD, NDAC } provide handshake

Interface Management

IFC, ATN, SRQ, REN, EOI } provide control of the interface system

Interface Functions

The chart below specifies level of implementation in terms of IEEE 488-1978 mnemonics. The Device Trigger, Device Clear and Remote/Local state responses are achieved by programming the 9915A for end-of-line interrupts on those conditions.

Source Handshake	SH1
Acceptor Handshake	AH1
Talker	T6
Listener	L4
Service Request	SR1
Remote/Local	RL1
Parallel Poll	PP2
Device Clear	DC1
Device Trigger	DT1
Controller	
System control	C1
IFC & Take charge	C2
REN	C3
Respond SRQ	C4
Miscellaneous control	C5
Extended talker	TE0*
Extended listener	LE0*

* The 9915A HP-IB card allows for interrupts on secondary commands. This allows a user to program the 9915A to respond to TE4 and LE2 extended talker and listener.

Transfer Rates

Maximum data rates for the 82937A HP-IB Interface are as follows:

Type	Input Bytes/s	Output Bytes/s
TRANSFER INTR	400	400
ENTER & OUTPUT	1400	3000
TRANSFER FHS	26.2K	25.5K

Addressing

The I/O ROM allows address information to be sent to all interfaces. The 82937A HP-IB Interface uses this addressing information to configure the addressable devices on the bus. There are a total of 32 valid addresses – 0 through 31. (Electrically, IEEE-488 systems can support only 15 devices including the controller.)

Interrupt Capability

When used with the I/O ROM, the 82937A is capable of responding to any or all of the following interrupt conditions:

- active controller
- active talker
- active listener
- service request (SRQ)
- interface clear (IFC)
- device clear (DCL, SDC)
- device trigger (GET)
- secondary command (SCG)

Switch Configuration

The following switches can be configured by opening the interface card. No switches are accessible from the outside.

Select Code – allows one of eight possible select codes to be set for the interface card. The select code range is 3 through 10 (1 is internal CRT, 2 is HP-85 internal printer). The factory select code setting for the 82937A card is 7.

Interface Bus Address – 5-bit talker/listener address. The factory-set bus address for the 82937A is 21 (decimal).

System Controller – allows the 82937A to act as a system controller or non-system controller. The factory setting is with the 82937A configured as system controller.

Jumper Configuration

The 82937A can be configured with a jumper wire to respond to a parallel poll. The designated bit is then asserted in response to a parallel poll when the interface is asserting SRQ. The card is configured with a parallel poll response on bit 0 of the data lines.

Accessories

The 82937A is shipped with a 2 m (6.6 ft) interface cable terminated with the standard HP-IB connector and metric fasteners. Various lengths of interface cables are available.

HP-IB Interface Statements

The I/O ROM adds a set of statements to the 9915A that accesses capabilities determined by the interface card being used. The following describes how the HP-IB interface card interprets these statements.

ABORTIO – sends Interface Clear (IFC) if system controller, else sends My Talk Address (MTA) if active controller, else stops handshaking data.

ASSERT – provides access to bus management lines.

CLEAR – sends Selective Device Clear (SDC) or Device Clear (DCL).

HALT – stops an interrupt type TRANSFER.

LOCAL – sends Go To Local (GTL) or Remote Disable (REN).

LOCAL LOCKOUT – sends Local LockOut (LLO) message.

PASS CONTROL – passes active control.

PPOLL – returns the value of a parallel poll.

REMOTE – Remote ENable (REN).
REQUEST – allows the programmer to set service request line and the serial poll response byte.
RESUME – drops the attention line (ATN).
SEND – allows sending of arbitrary data/command sequences over HP-IB.
SPOLL – returns the value of a serial poll conducted on an HP-IB device.
TRIGGER – sends Group Execute Trigger (GET) message.

Serial Interface

The HP 82939A Interface provides bit-serial communication between the 9915A computer and asynchronous EIA RS-232-C devices such as data terminals and modems. Standard data rates range from 50 to 9600 bits/second (baud) and can be switch-selected or programmed via a CONTROL register. Allowable data formats include 5, 6, 7 or 8 bits/character and 1 or 2 stop bits.

Information can be sent and received (in true full duplex mode) in EIA RS-232-C compatible voltage levels or with 20-ma current loop configurations. Two 20-ma current sources in the interface allow connection to virtually any current loop device. The HP 82939A uses an interface processor to provide efficient management of the serial interface.

Data Rates and Formats

All signals present at the connector conform electrically to EIA RS-232-C and CCITT V.24 specifications. The interface operates in an asynchronous mode providing 5-, 6-, 7- or 8-bit data formats with 1 or 2 stop bits and odd, even, zero, one and no parity modes.

Standard data rates available are:

50	75	110	134.5
150	200	300	600
1200	1800	2000	2400
3600	4800	7200	9600

In addition to these standard baud rates, the user can select one from a set of 65 533 different baud rates ranging from 1.76 baud to 38 400 baud. The standard baud rates are either switch selectable or programmable. The optional 65 533 baud rates are only programmable.

Modem Control Lines

RTS – Request To Send
CTS – Clear To Send
DSR – Data Set Ready
DTR – Data Terminal Ready
DCD – Data Carrier Detect
DRS – Data Rate Select

Transfer Rates

The 82939A does not support TRANSFER FAST HANDSHAKE. Maximum data rates for the serial interface are as follows:

Type	Input Bytes/s	Output Bytes/s
TRANSFER INTR	1000	400
ENTER & OUTPUT	1400	1500
TRANSFER FHS	none	none

These data rates mean that the serial interface can support incoming data rates of 9600 baud (with interrupt mode transfers) and 15000 baud with ENTER (into a string variable).

Addressing

The I/O ROM allows address information to be sent to all interfaces. The 82939A Serial Interface does not use this addressing information. An error will result if address information is sent to the serial interface.

Interrupt Capability

When used with the I/O ROM, the 82939A can be programmed to respond to any or all of the following interrupt conditions:

- BREAK received
- Framing error
- Parity error
- Received data available
- Auto disconnect
- change of modem line DCD or RTS
  Data Carrier Detect (on Opt. 001 interface)
  Request To Send (on standard interface)
- change of modem line DSR or DRS
  Data Set Ready (on Opt. 001 interface)
  Data Rate Select (on standard interface)
- change of modem line CTS or DTR
  Clear To Send (on Opt. 001 interface)
  Data Terminal Ready (on standard interface)

Switch Configuration

The following switches can be configured by opening the interface card. No switches are accessible from the outside.

Select Code – the factory-set select code for the 82939A is 10.
Baud Rate – a 4-bit switch selects standard baud rates from 50 to 9600. The factory set baud rate is 300 baud.
Line characteristics – a 3-bit switch selects 5, 6, 7 or 8 bits/character and 1 or 2 stop bits. The factory setting is 7 bits/character with 1 stop bit.
Parity – a 3-bit switch selects even, odd, one, zero or no parity. The factory setting is odd parity.
Auto handshake – a 1-bit switch enables or disables automatic handshaking on the modem control lines. The factory setting disables auto handshaking.

Options

The 82939A is shipped with a 2 m (6.6 ft) interface cable terminated with the standard RS-232-C female (DCE) connector. The 82939A Option 001 is shipped with a 2 m (6.6 ft) interface cable terminated with a RS-232-C male (DTE) connector. The 82939A Option 002 is shipped with a 4 m (13.1 ft) unterminated interface cable for current loop operation.

Serial Interface Statements

The I/O ROM adds a set of statements to the 9915A that accesses capabilities determined by the interface card being used. The following describes how the serial interface card interprets these statements.

ABORTIO – abort all TRANSFERs in progress (to the specified card) and drop all modem lines.
ASSERT – write to modem control register.
HALT – abort all TRANSFERs in progress (to the specified card) but leave all modem lines unchanged.
REQUEST – send a BREAK using the parameter to determine the length of the BREAK.
RESUME – enable the transmitter.
SEND – allows sending of arbitrary data sequences over the serial interface.

GPIO Interface

The HP 82940A Interface provides the 9915A with 16 bits of latched output data and 16 bits of bi-directional data (latched output, non-latched input). The HP 82940A uses an interface processor for efficient management of the interface. The HP 82940A Interface can achieve data transfer rates of up to 19K bytes/second (absolute maximum).

Data Input/Output

There are 16 bi-directional data lines and 16 output-only data lines. The output-only lines provide high current capability, using open-collector transistors.

Electrical Characteristics for Bi-directional Lines
(Input characteristics also apply to FLG and ST lines)

Parameter	Min.	Max.	Units
Input Low Voltage	0.0	0.8	V
Input High Voltage	2.0	5.0	V
Input Low Current		0.6	mA
Output Low Voltage @ 4.5 mA	0.45	V	
Output High Voltage @ −450 μA	2.4		V
Output Low Current		4.5	mA
Output High Current		−450	μA

Electrical Characteristics for Output-Only, CTL, $\overline{OUT}$, and $\overline{RES}$ Lines

Parameter	Min.	Max.	Units
Output Low Voltage @ 20 mA		0.5	V
Output High Voltage (open collector)		5.0	V
Output Low Current		20	mA
Output Leakage Current		40	μA

Control Lines

Twelve lines provide control information between the peripheral and the computer. The outgoing lines are electrically equivalent to the open-collector, output-only data lines. The incoming lines are electrically equivalent to the bi-directional data lines. The control lines and their meanings are:

$\overline{OUTA}$, $\overline{OUTB}$ – indicates the direction of the data transfer on ports A and B.
CTLA, CTLB – indicates that the computer is ready for input or that data is ready for output.
FLGA, FLGB – indicates that the peripheral has completed its operation.
CTL0, CTL1 – indicates that the computer is ready for input or that data is ready for output.
ST0, ST1 – indicates that the peripheral has completed its operation.
$\overline{RESA}$, $\overline{RESB}$ – used to reset peripherals under program control.

Transfer Rates

The maximum data rates for the 82940A Interface are as follows:

Type	Input Bytes/s	Output Bytes/s
TRANSFER INTR	400	400
ENTER & OUTPUT	1400	3000
TRANSFER FHS	18.0K	19.0K

Addressing

The I/O ROM allows address information to be sent to all interfaces. The 82940A GPIO Interface uses this addressing information to select which port is being used for the data transfer, the width of the data path (8 or 16 bits), and which handshake lines are to be used. There are a total of 16 valid addresses – 0 through 15.

Interrupt Capability

When used with the I/O ROM, the 82940A is capable of responding to any or all of the following interrupt conditions:

- FLGA
- FLGB
- ST0
- ST1
- Received parity error

Switch Configuration

The following switches can be configured by opening the interface card. No switches are accessible from the outside.

Select Code – the factory select code setting for the 82940A card is 4.
Data line sense – a 1-bit switch allows the data lines to use either positive-true (factory setting) or negative-true logic.
Flag line sense – a 1-bit switch allows the flag lines to use either positive-true (factory setting) or negative-true logic.
Control line sense – a 1-bit switch allows the control lines to use either positive-true (factory setting) or negative-true logic.
Handshake mode – a 1-bit switch allows selection of complete or partial handshake mode. The factory setting is complete handshake.
Output enable – a 1-bit switch allows the programmer to enable for output. The factory setting is output disabled.
Address – a 3-bit switch allows the interface to power up with its address (which determines the handshake lines and data port configuration) set to 0 through 7 (note that 0 through 15 are allowed under program control). The factory setting is address 6.

GPIO Interface Statements

The I/O ROM adds a set of statements to the HP-85 that accesses capabilities determined by the interface card being used. The following describes how the GPIO interface card interprets these statements.

ABORTIO – aborts the current TRANSFER and returns the handshake lines to their idle state.
ASSERT – allows access to control lines.
CLEAR – sets $\overline{RESETA}$ or $\overline{RESETB}$ line depending on whether the device address was even or odd.
HALT – stops an interrupt type TRANSFER and leaves the handshake and data lines in an undefined state.
SEND – allows sending of arbitrary data sequences over the GPIO interface.

Binary Coded Decimal Interface

The HP 82941A Interface provides the 9915A with 11 digits of 4-bit BCD input or output data plus four, sign bits for one or two channels. The HP 82941A uses an interface processor to provide efficient management of the interface. The HP 82941A Interface can achieve data transfer rates of up to 1.4K readings/second (absolute maximum).

Data Input/Output

Twelve bi-directional ports, of four lines each, provide data input and output.

Electrical Characteristics for Data Lines

Parameter	Min.	Max.	Units
Input Low Voltage	0.0	0.8	V
Input High Voltage	2.0	5.0	V
Input Low Current		0.6	mA
Output Low Voltage @ 4.5 mA		0.45	V
Output High Voltage @ −450 µA	2.4		V
Output Low Current		4.5	mA
Output High Current		−450	µA

Control Lines

Six lines allow for control information to be passed between the peripherals and the computer. The output control lines are implemented with standard TTL gate 7405 open-collector drivers. The control lines and their meanings are:

I/OA, I/OB – indicates the direction of the data transfer on channels A and B.
CTLA, CTLB – indicates that the computer is ready for input or that data is ready for output.
FLGA, FLGB – indicates that the peripheral has completed its operation.

Electrical Characteristics for CTL and I/O Direction Lines

Parameter	Min.	Max.	Units
Output Low Voltage @ 13 mA		0.4	V
Output High Voltage @ −1.0 mA	2.4		V
Output Low Current		13	mA
Output High Current		−1.0	mA

Electrical Characteristics for FLG Lines

Parameter	Min.	Max.	Units
Input Low Voltage	0.0	0.8	V
Input High Voltage	2.0	5.0	V
Input Low Current		4.0	mA

Data Formats

The 82941A supports two pre-defined data formats and a wide variety of user-configurable data formats. The two pre-defined formats are:

Single channel – 8-digit signed mantissa with 1-digit signed exponent and a 1-digit function code.
Dual channel – each channel consists of a 4-digit signed mantissa and a 1-digit function code.

Transfer Rates

The maximum data rates for the 82941A BCD Interface are as follows:

Type	Input Bytes/s	Output Bytes/s
TRANSFER INTR	400	400
ENTER & OUTPUT	1400	3000
TRANSFER FHS	20K	22K

Addressing

The I/O ROM allows address information to be sent to all interfaces. The 82941A BCD Interface uses this addressing information to select which channel is being used for the data transfer and which of the fields are being read – numeric data (mantissa, exponent and sign information) or function code. There are a total of seven valid addresses – 0 through 6.

Interrupt Capability

When used with the I/O ROM, the 82941A is capable of responding to any or all of the following interrupt conditions:

- channel A most significant function digit, bit 0.
- channel A most significant function digit, bit 1.
- channel A most significant function digit, bit 2.
- channel A most significant function digit, bit 3.
- channel B most significant function digit, bit 0.
- channel B most significant function digit, bit 1.
- channel B most significant function digit, bit 2.
- channel B most significant function digit, bit 3.

Device Control

The 82941A Interface allows the user to control his BCD device via one of the BCD digits. To OUTPUT control information to the device would require opening the card and reconfiguring it by setting a switch. Port 10, accessed via ASSERT, allows the user to control his device without this reconfiguration.

Switch Configuration

The following switches can be set by opening the interface card. No switches are accessible from the outside.

Select Code – the factory select code setting for the 82941A card is 3.
Format – a 1-bit switch selects standard (1 channel) or optional (2 channel) data format. The factory setting is standard.
Handshake – a 1-bit switch selects handshake on the leading or trailing edge of the handshake lines. The factory setting is trailing edge.
Data line sense – a 1-bit switch allows the data lines to use either positive-true (factory setting) or negative-true logic.
Sign bits sense – a 1-bit switch allows the sign bits to use either positive-true (factory setting) or negative-true logic.
Control line sense – a 1-bit switch allows the control lines to use either positive-true (factory setting) or negative-true logic.
Flag line sense – a 1-bit switch allows the flag lines to use either positive-true (factory setting) or negative-true logic.
Output Enable – a 1-bit switch disables (factory setting) or enables data ports for output. It does not affect output via Port 10.

BCD Interface Statements

The I/O ROM adds a set of statements to the 9915A that accesses capabilities determined by the interface card being used. The following describes how the BCD interface card interprets these statements.

ABORTIO – aborts the current TRANSFER and returns the interface lines to a "tri-state" high impedence state.
ASSERT – allows access to control lines and Port 10.
HALT – stops any TRANSFER (on the specified card) and leaves the handshake and data lines unchanged
SEND – allows sending of arbitrary data sequences over the parallel interface.

Development Aids

Program Development Kits

The HP-85 and the 9915A can both be configured as development systems. Two development kits are available to simplify ordering the proper components.

98150A Program Development Kit *(for HP-85F)*

09915-90010 System Development Manual
98151A Program Development ROM
09915-10010 Tape Duplication and EPROM Programming Software Pack

98150B Program Development Kit* *(for 9915A)*

09915-90010 System Development Manual
00085-90002 HP-85 Operating and Programming Manual
00085-90142 I/O Programming Guide
09915-10010 Tape Duplication and EPROM Programming Software Pack
98155A Accessory Keyboard

Tape Duplication and EPROM Programming Software Pack

This software package (09915-10010) provides a binary program and BASIC language utilities for duplicating tapes and programming user PROM via an external PROM programmer. A binary program allowing source-form storage of programs is also provided.

Tape Duplication

The tape duplication programs allow use of a single HP-85 or 9915A as a master and up to 10 HP-85s or 9915As as slaves in a tape duplication setup. A tape inserted into the master tape drive is read and transferred via the HP-IB to the slaves. Each slave creates a copy of the master tape. There are two sets of utility programs (master/slave pairs) which offer the following capabilities:

General purpose duplication allows several flexible options in copying. Files may be appended to a tape or the tape may be initialized before duplicating.

Read-after-write verification of copied tapes is available. In addition, empty records and files may be deleted, and files may be copied selectively from the source tape.

Fast duplication is used in production applications where speed is important. An entire tape is copied in one operation, and the source tape must not contain null files or empty records. Tape verification is performed after copying.

EPROM Programming

This program converts the desired program file into the proper image for a PROM file and stores it as data on the tape. The data is then formatted and passed to a PROM programmer via the serial interface. Example programs illustrate this process. EPROMs of the 2516, 2716 or 2732 type (or equivalents) can be used for program storage in the 9915A. The eight EPROM sockets on the supplied board allow up to 32K bytes of storage.

9915A Specifications

Configuration Guide

Mass Storage

The 9915A Controller uses PROM as the standard form of program storage. Up to 32K bytes of PROM may be installed in the 9915A on the supplied printed circuit board.

Option 001 provides a tape drive for program or data of up to 195K bytes on a single cartridge. In the event of program changes, new tapes can be more easily supplied than new PROMs although concerns about tape backup must be addressed, especially if programs are secured.

Comparison – PROM and Tape Mass Storage

	PROM	Tape Drive (Opt. 001)
Maximum storage	32K bytes	195K bytes
Operating temperature	0 – 55°C	0 – 40°C
Security	Automatic	Programmable
Typical life cycle	Indefinite	50 – 100 hours of use
Average access time	< 1 second	9.3 seconds
Data storage?	No	Yes

Operator Interface

The standard front panel of the 9915A provides a minimal operator interface. There are eight user-definable keys (four shiftable keys) and eight programmable lights. A front panel insert serves as a custom label area for the keys and lights. AUTOSTART and SELF TEST can be initiated from the front panel.

Option 002 offers the hardware needed to implement a custom operator interface. This option includes a keyboard matrix, composite video output, speaker output, and front panel light and key outputs.

	Standard Panel	Opt. 002 Interface
User definable keys	8 (4 shiftable)	76 with external keyboard (more with shift and control keys)
Display	8 programmable lights, label area	External CRT for graphics and text
Audio output	None	Programmable tone, duration
Remote lights, AUTOSTART?	No	Yes

Memory

Standard memory is 16K bytes of user read/write memory. The 82903A Memory Module adds an additional 16K bytes for a maximum total of 32K bytes.

I/O Cards

There are five interface cards available for the 9915A. The choice of interface depends on the input/output format desired. The cards are:

- 82937A HP-IB Interface allows interfacing to a wide variety of instruments and peripherals which use the IEEE 488-1978 interface standard.
- 82939A Serial Interface (RS-232-C) provides bit serial communication with asynchronous devices such as terminals and modems.

- 82940A GPIO Interface provides 16 bits of latched output and 16 bits of bi-directional data for communication with a wide variety of devices.
- 82941A BCD Interface is used with devices which present or receive data in binary coded decimal format.
- 82949A Printer Interface provides for connection with 8-bit parallel (Centronics-type) printers.

Option ROMs

The 9915A has the Input/Output ROM and the Program Development ROM installed as an integral part of the controller. Each of the following option ROMs can be installed in the 9915A.

- Matrix ROM (00085-15004) provides the statements necessary for mathematical manipulation of matrices.
- Plotter/Printer ROM (00085-15002) provides a simple path for outputting data to an external digital plotter that uses HP-GL, such as the HP7225A, or a printer (HP9876, for example).
- Mass Storage ROM (00085-15001) performs the necessary formatting to use external mass storage devices with the 9915A. For example, the 9895A Flexible Disc Drive can be used for on-line data storage up to 2M bytes.
- Advanced Programming ROM (00085-15005) provides local-environment subprograms, string arrays, program-editing enhancements, cross referencing and flags.
- Assembler ROM (00085-15007) allows development of assembly-language programs either as binaries or user-defined option ROMs. The user-defined option ROM (82929A Programmable ROM Drawer) uses EPROM and can be used concurrently with the internal EPROM board (used for application programs). An optional system monitor (82928A) eases assembly-language programming.

Accessory Keyboard

For applications requiring alphanumeric input to the 9915A, the 98155A keyboard provides a simple solution. This keyboard connects directly to the rear panel keyboard connector provided with the Option 002 Operator Interface. No special software is needed to use the keyboard.

Development Stations

There are basically two ways to write software for the 9915A. First, an HP-85 Desktop Computer can be used to write and test programs. As an alternative, the 9915A with added accessories can be used as its own development station.

The HP-85 is self contained and portable. It can be used as a general purpose desktop computer after program development is completed. The 9915A, when configured for program development, requires more bench space. However, it can be used as a spare controller for the intended application.

All features of the 9915A, except remote front panel, can be emulated on the HP-85. Slight differences in program execution (e.g., tape is slower than PROM) may exist.

What is Needed

HP-85F (includes I/O ROM and HP-IB I/O card)

- 98150A Program Development Kit.
- Any option ROMs or add-on memory which will be used in the 9915A.
- I/O Cards (other than HP-IB) may be substituted for the HP-IB card, depending on what is needed for your application. The HP-IB card interfaces to the 9895A Flexible Disc Drive, the 7225A Plotter, and the 9876A Printer.

9915A

- 98150B Program Development Kit (to be announced).
- 82937A HP-IB I/O Card or other card, as needed. (HP-IB is useful for interfacing to an external printer.)
- Data Display Monitor, not supplied by HP (see System Development Manual for information).
- Printer (HP9876A, for example).

Software Duplication

There are three media for the storage of programs: PROM, tape, and flexible disc.

Because the Mass Storage ROM allows copying from disc to disc or tape to disc, no special duplication effort is needed. Copying tape to tape or tape to PROM is accomplished in a less direct manner. The Tape Duplication and EPROM Programming Software Pack (09915-10010) is included in the program development kits. This software, plus the equipment listed below, allows easy software duplication.

Tape Duplication

At least two HP-85s or 9915As Opt. 001 or any combination of the two are required. Each controller must have the HP-IB I/O card. One system acts as a master, and up to 10 slaves may be included. Thus, up to 10 copies may be made simultaneously. Each system, whether slave or master, can be either of the following two minimum equipment combinations:

- HP-85F (includes HP-IB Interface) and 98151A Program Development ROM or
- 9915A, Opt. 001, and 82937A HP-IB Interface

EPROM Programming

Programs are downloaded as data through the serial interface to a PROM programmer. Software from the program development kit facilitates the process.

- HP-85F Opt. 001 (serial interface in place of HP-IB) and PROM Programmer or
- 9915A Opt. 001, 82939A Serial Interface and PROM Programmer.

Ordering Information

Item	Part No.
Controller	9915A
Tape Drive	Opt. 001
Operator Interface	Opt. 002
HP-IB Interface	82937A
Serial Interface	82939A
GPIO Interface	82940A
BCD Interface	82941A
Program Development Kit for HP-85F	98150A
Program Development Kit for 9915A	98150B
Program Development ROM for HP-85	98151A
Package of 10 EPROM Boards	98154A
Keyboard	98155A
Label Area Insert	7121-0714

For assistance call the HP regional office nearest you: Eastern 301/258-2000, Midwest 312/255-9800, Southern 404/955-1500, Western 213/877-1282, Canadian 416/678-9430. Or write to Hewlett-Packard, 3404 East Harmony Road, Fort Collins, Colorado 80525; in Europe, Hewlett-Packard GmbH, Desktop Computer Division, Herrenberger Strasse 110, D-703 Boeblingen, Postfach 1430, West Germany; elsewhere in the world, Hewlett-Packard Intercontinental, 3495 Deer Creek Road, Palo Alto, California 94304.

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