JUNE 1976

HEWLETT-PACKARD JOURNAL

Mid-Range Calculator Delivers More Power at Lower Cost

Its design takes advantage of the latest technology, principally a single-chip microprocessor.

by Douglas M. Clifford, F. Timothy Hickenlooper, and A. Craig Mortensen

NEAR THE MIDDLE of the spectrum of calculator users is the user who needs moderate computing power and control capability at a modest price. HP's Model 9810A Calculator has met these needs for about five years. During that period, significant advances in technology have occurred, making it possible to provide not only the 9810A's level of performance but also many more features at a much lower cost. This is done in the new Model 9815A Calculator (Fig. 1).

How is it possible to put this kind of power and flexibility into a calculator that is about one-third the size of its predecessors and costs about one-half as much? A single-chip microprocessor gets most of the credit. The microprocessor reduces the hardware needed to control the calculator and its internal peripherals such as the printer and the display.

Smaller internal peripherals also contribute to the new calculator's small size. A major improvement is the built-in tape transport system, which uses the new 3M DC-100 mini-cartridge. 96,384 bytes of information can be stored on each tape cartridge. The machine searches for data at 60 inches per second, which means that the worst-case access time from the be-

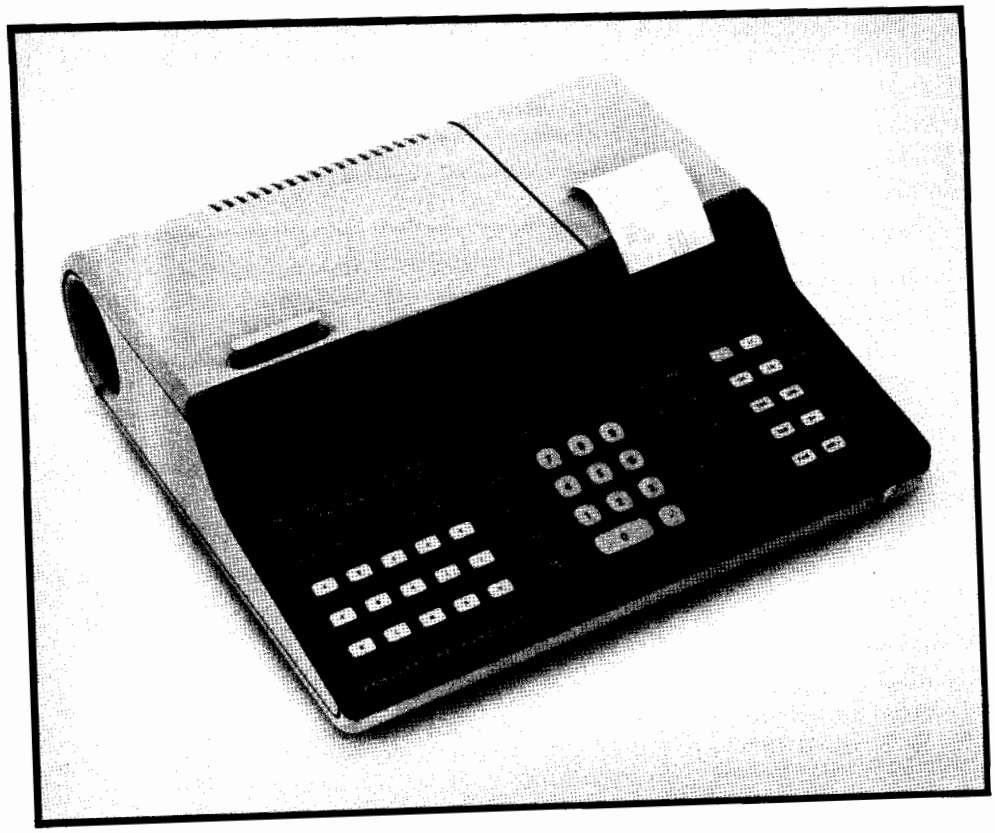


Fig. 1. *Model 9815A Calculator includes as standard many formerly optional features, including printer, magnetic tape unit, and 15 special function keys. The keyboard language is reverse Polish. Memory is expandable from 472 program steps to 2008 program steps.*

ginning of a tape to the end is only 28 seconds. The average time to find and read a file is less than nine seconds.

Despite its small size and simple appearance, the 9815A includes features formerly found only in much larger calculators. Instead of the plug-in read-only memories (ROMs) often used to expand a calculator's language, the standard 9815A Calculator includes all of the most popular options of its predecessors. Mathematical functions are included, as are 15 user-definable keys. The thermal printer and display are standard. The ability to drive external peripherals can be added with the I/O option. This option accepts any two of a series of I/O cards that mate with most of the existing HP calculator peripherals.

Reverse Polish Notation

Like its predecessor the 9810A, the new 9815A Calculator uses reverse Polish notation (RPN). The RPN language is more efficient than other computing languages in terms of the amount of memory needed to store a program. Programming efficiency implies reduced memory cost, an important consideration for a calculator in this class.

In the 9815A further programming efficiency is realized by combining several keystrokes into single or dual program steps. As the user enters the key sequence, the calculator automatically combines logical sequences of key codes and enters these combined instructions into the memory. Fig. 2 shows key entries that are combined into each program step of a typical program.

In most cases, program instructions only take a single step. However, certain memory reference instructions take two program steps—for example, STO R12, store the contents of the display register into register number 12; or STO+I R125, add the contents of the display register to the register that is pointed to by the contents of register 125 (indirect addressing). Because of the combining of key entries into program statements, the average 9810A program can be written in approximately 30% less memory space on a 9815A.

```
0283 LBL
---- 01
0285 IF SFG 8
0287 GOTO    0362
0288 0
0289 STO I   R010
0291 1
0292 STO     A
0293 FOR     A+F
0294 STO+ I  R011
0296 PCL T   B
0298 PLOT
```

Fig. 2. *Many keystroke sequences are combined into one or two program steps. These are a few examples.*

Editing

Editing features such as INSERT, DELETE, and LIST allow the user to modify programs and correct mistakes. The 9815A automatically corrects branching statements during editing.

The program or segments of the program can be listed on the built-in 16-character alphanumeric printer. The listing is in easy-to-read mnemonics. The STEP and BACK STEP keys allow the user to walk through the program either in program mode or in run mode.

Software Enhancements

Several advanced programming features were added to the 9815A to make it easy to generate a complex program. The FOR-NEXT loop is generally associated with higher-level languages such as FORTRAN. When implemented on a reverse Polish machine, it adds significantly to the programming power of the calculator. The FOR-NEXT instruction allows the user to execute the same sequence of program steps a predetermined number of times with one of the variables incremented through a programmed range of values. The 9815A allows three nested FOR-NEXT loops.

Eight selectable flags are available to the user. All eight flags can be manually set or reset and interrogated. However, four of the flags have other functions which provide special programming aids. Normally, if an error condition is detected in a running program, the program will stop and the calculator will print out the error message. One of the special flags will override this condition and allow the program to continue execution. Instead of stopping the execution, another of the special flags is set when an error condition is suppressed. This second flag can be interrogated in the program and alternate action taken.

Another special flag can be toggled during program execution, allowing the user to modify a program sequence during execution. The last special flag is a data entry indicator. The flag is set every time a STOP statement is encountered. Any manual data entry will reset this flag, but if the RUN key is pressed before a data entry, the flag will remain set. This can be used to terminate a string of data entries in a program.

Auto Start

The 9815A Calculator has a new feature called auto start. When the calculator control switch is set to the auto start position, and the power switch is turned on, the calculator automatically rewinds the tape, loads the program on file 0, and begins execution of that program.

Another use of auto start is for unattended operation. Say the calculator program used to control a system resides on the tape cartridge and contains an initialization routine for the other devices in the sys-

tem. If a power failure should occur, the system will automatically power up again and be reinitialized by the auto start program on the tape cartridge. This provides a nonvolatile memory for the system.

User-Definable Functions

Another way that a calculator can be tailored to a particular application is by the use of user-definable functions. Such a function is a program segment that can be called by a single key entry. The 9815A has 15 keys that can be user-defined.

Cartridge Tape System

The tape system of the 9815A Calculator represents a significant advance in both capacity and capability over magnetic cards. the tape drive was designed and developed by Hewlett-Packard's Calculator Products Division, to work with the new 3M DC-100 mini-cartridge. It was determined that a level of performance below that of the 9825A Calculator (see article, page 2) would be adequate, so the search speed was reduced to 60 ips and the read/write speed to 10 ips. The recording density was set at 500 bits per inch. Because of these reduced demands all of the encoding and decoding of the bits can be done in firmware. Also, a frequency-lock control loop is used for the motor control instead of a more costly dc servo (more about this later).

Thin-Film Printer

To fit the overall objectives of low cost, small size, and high performance, it was necessary to develop a new printer, one with alphanumeric capability to enhance the programming language and provide easy-to-read program listings. A dot-matrix thermal printing technique is used. The paper advance mechanism, which in previous models had used large expensive stepper motors, has been redesigned. The new mechanism relies upon the force of a magnetic field to pull a metal armature in toward the poles of the magnetic core. The motion of the armature is coupled to a ratchet mechanism that rotates the paper roller a fixed distance with each cycle of the armature. The volume of the entire motor is less than 11 in.[3]

The print head is a ceramic substrate on which a pattern of thin-film resistors is deposited. Custom bipolar driver chips are also mounted on this substrate. The dot information for the row to be printed is serially loaded into the chips, which drive the appropriate resistors to heat the thermal paper. The paper is advanced one position, and the cycle is repeated. For the 5 × 7 dot matrix used, it takes seven advances to print a line of characters and three more advances between lines. The printer is controlled by the microprocessor and the dot information for the various characters is stored in ROM. The print speed is 2.8 lines per second.

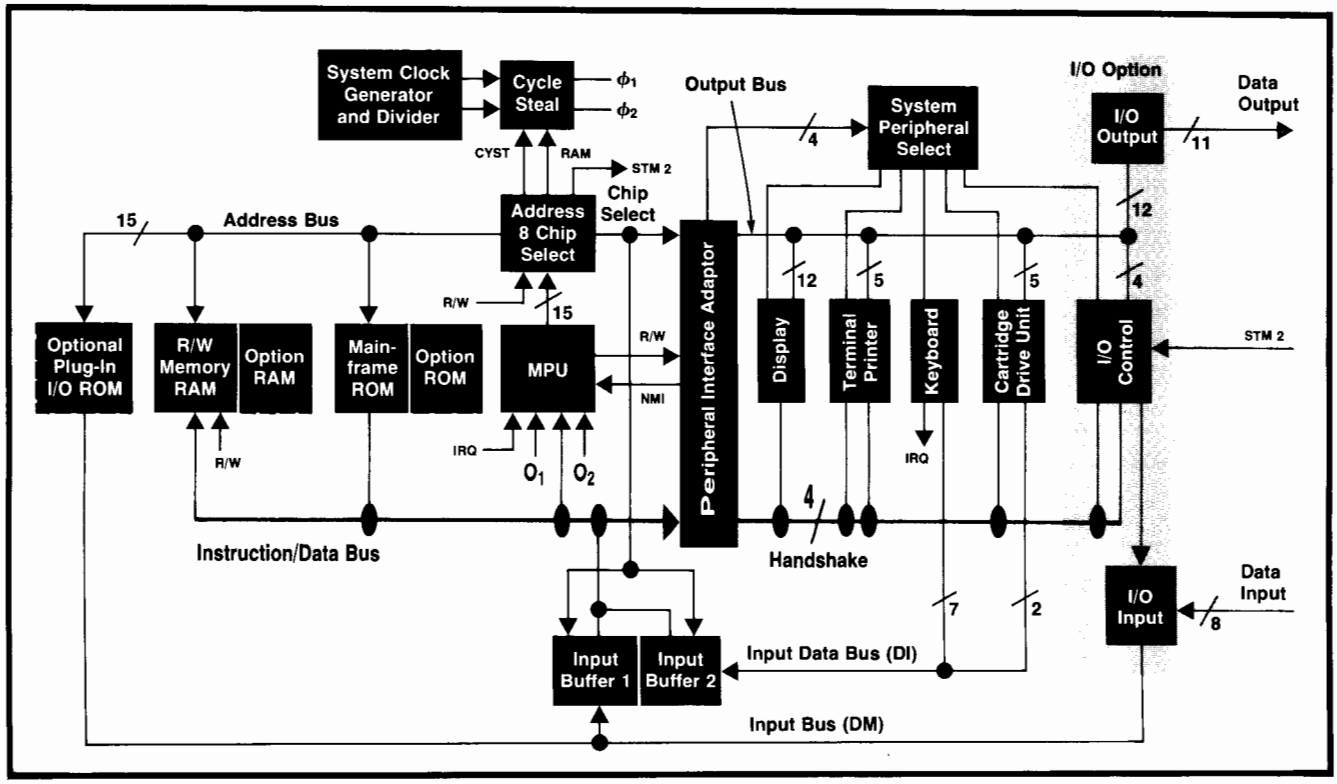


Fig. 3. *Model 9815A Calculator is based on a commercially available 8-bit microprocessor. Eight read-only memories contain the instructions necessary to implement the calculator's functions.*

Keyboard

The keyboard was a critical component of the 9815A design because the case was too shallow for the standard key switches. A snap action key switch has been used on HP hand-held calculators for many years, and it was decided to expand this technology to a full-size key panel.

The springs are fabricated from strips of a copper alloy that are preformed into an arch. These strips are welded onto a printed circuit board in a bowed position. The key depresses this arch until it buckles and makes contact with the pad under the spring. To minimize cost and tolerance variations from key to key, an automatic welder was developed in conjunction with an outside vendor. The welder can cut, preform, weld, and test a key switch in seven seconds.

The same key switch design is used in the 9825A Calculator.

Architecture

Fig. 3 is a block diagram of the 9815A. The system can be divided into three blocks, the first being the microprocessor and memory. The machine uses a commercially available 8-bit microprocessor. The processor chip has an 8-bit bidirectional data bus and a 16-bit address bus. Only 15 of the 16 addresses are used, making it possible to address 32K bytes of memory. The memory is divided into a block of random-access read/write memory (RAM) and a block of ROM. In the basic machine there are six RAM chips of 1K bits each, organized in a 256×4 configuration. This gives 768 bytes of RAM. 296 bytes are used by the system for general registers, subroutine return vectors, keyboard buffer, flag conditions, and other execution variables, and the remaining 472 bytes are available for user data registers or program storage. The same memory locations can be used for data or for program storage. The user can specify the boundary that divides the memory according to his current program needs. If a routine requires more data registers and the execution program is small, the user can swap program steps for registers at the rate of eight steps per register. A read/write memory option expands the calculator memory to 2008 program steps or 251 registers.

Eight ROMs contain the microprocessor instructions needed to execute the calculator's functions. These ROMs contain 16K bits each, organized in a 2K ×8-bit structure that interfaces easily to the 8-bit data bus. The main calculator routines are contained in seven ROMs. The eighth ROM can be installed at the factory to make it possible to list Katakana and Cyrillic characters on the internal printer and on optional external line printers.

The second block of the system is the internal peripherals, which consist of the 16-digit gas discharge display, the 16-character alphanumeric thermal printer, the 63-position keyboard, and the bidirectional tape drive. Control of these devices is the job of an I/O chip that is separate from the microprocessor. This interface chip provides a 12-bit I/O bus to the peripherals. This same bus also goes to the I/O option to control external peripherals.

Since the microprocessor can only execute one routine at a time, only one peripheral can be active at any instant. For example, when the tape cartridge is searching for a file, the printer and display are disabled. The only exception to this is the keyboard, which is scanned by special hardware and can interrupt the processor when it senses a key closure. This allows the user to terminate a print cycle or a tape search with the STOP key.

The third block is the optional I/O interface module. This module provides twelve output lines and eight input lines per channel for controlling external peripherals. There are two such channels. The module accepts any of six available I/O cards. These cards control most of the calculator peripherals plus a wide variety of instruments and custom equipment. One card is an interface to the HP-IB, HP's implementation of IEEE standard 488-1975.

Input/Output

Interfacing power was an important consideration in the development of the 9815A Calculator. Examining past interfacing needs and present desires, it was determined that two I/O slots would fill the interfacing requirements. The internal I/O hardware was tailored to give needed flexibility and transfer rates.

The internal I/O control hardware consists of output data latches, handshake logic, and channel select logic (see Fig. 4). An I/O instruction ROM is included on each plug-in interface card. This 2K×8-bit ROM customizes the hardware for the device being interfaced. Also included on the external interface card are output data drivers and an input data latch.

Interfaces available for the 9815A include special interfaces for the 9862A Plotter and the 9871A Printer, and four general interfaces: 8-bit I/O, BCD, HP-IB, and RS232C.

The plotter interface has a major new feature, digitizing mode, which allows the pen of the plotter to be positioned over a point and have the scaled coordinates of that point entered into the calculator stack for processing. This mode is useful for approximating areas or line segment lengths from published material or photographs.

The 9871A Printer/Plotter can print or graphically plot data in either single or multiple copies. The interface ROM provides convenient instructions to control the printing and plotting functions of the printer from the keyboard or a user program. A jumper on the

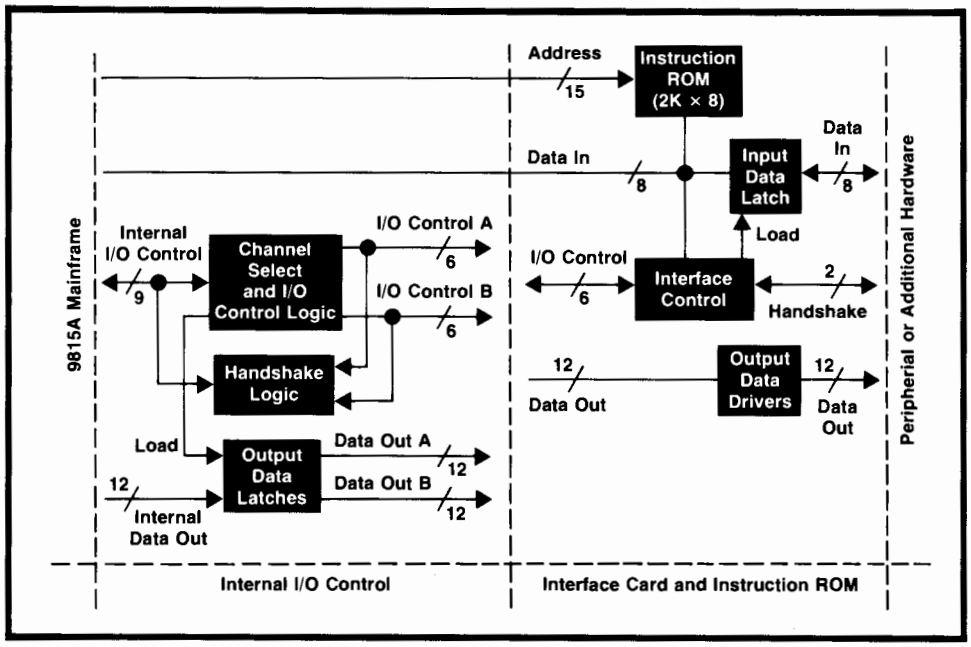


Fig. 4. *An I/O option adds the ability to drive external peripherals. Two I/O channels are provided; each accepts one of six available interface cards.*

interface card allows the user to pass parameters in either inches or centimetres.

The 8-bit general I/O interface is a bit-parallel, character-serial interface to a wide variety of peripheral devices, such as readers, punches, printers, and digitizers. One character of buffer storage for both input and output data is provided. Normal data instructions include full formatted output of numeric data along with a full ASCII character set. Binary data I/O is also provided along with binary data operating instructions. Input data is read under free field format with the additional feature of having user-definable delimiters. The user can define up to three delimiters to be used in reading numbers. Logic sense can be changed by user instructions. Three different handshake modes are available: one for corporate handshake, one for corporate handshake disabled, and a new one called peripheral mode, that allows the 9815A to act like another calculator's peripheral. A special four-column list command lists the user program in a four-column-wide, 50-lines/page format useful for documentation and debugging.

The RS232C interface is formed by adding hardware to the 8-bit general I/O interface to serialize the 8-bit parallel output data and form 8-bit parallel data from serial input data. Character buffers are provided for both input and output data. The serial data is RS232C compatible with changeable baud rates (110 to 3600), selectable data formats, and parity.

The BCD general-purpose interface is compatible with a large number of character-parallel BCD devices. Because of its flexible data formating and manipulating instructions, it is also used for custom interfacing. The interface provides 40 parallel data input lines and eight parallel data output lines. Both input and output data are buffered. The CTL and FLG lines have programmable logic senses and three different handshake modes are provided. There are several ways to input data from a BCD instrument, depending on speed and timing requirements. A software interrupt is provided for taking less than 100 readings per second. This allows the calculator to be taking a reading and doing other computations at the same time. Overload or illegal characters can be checked automatically by setting up a masking code for the tests through the MASK instruction. If the BCD instrument or device is fast and a block of data needs to be read rapidly, there are two commands for reading blocks of data at over 2000 nine-digit readings/second. This data goes directly into memory; it can then be stored on the data cartridge or translated immediately and processed. There are also commands for inputting and outputting 8-bit binary data in blocks at rates exceeding 5000 bytes/second.

The HP-IB interface provides for connecting up to 14 other instruments or devices in a system configuration for testing, measurement, or other purposes. This interface conforms to IEEE standard 488-1975. The calculator may or may not be the system controller; it can pass and receive control. Data may be sent or received as strings at speeds exceeding 2000 bytes/second. Commands for building and manipulating strings are included in the instruction ROM. An auto address feature allows the calculator to address itself as talker or listener. Peripheral devices are assigned select code numbers that are translated in the ROM to bus addresses for user simplicity. When the 9815A is not the system controller, a device clear command (DCL) will return the calculator to the power-up state, allowing an auto start operation;

this is useful in remote sites having power-fail/restart capabilities or when an external restart command is available.

Cartridge Tape Electronics

The 9815A motor speed control system is configured as a frequency-locked loop (FLL). The FLL is a closed-loop electronic servo with a speed-proportional output frequency that is frequency-locked to an input reference frequency. A block diagram of the servo loop is shown in Fig. 5.

Division of the crystal-controlled system clock creates two frequency references, 62.5 kHz for the tape search speed of 64.6 inches per second, and 10.4 kHz for data transfer at 10.8 inches per second. The appropriate reference frequency is gated into the loop under microprocessor control.

Motor capstan motion is translated into frequency feedback information by means of a 1000-line optical tachometer disc coupled to the motor shaft.

Servo operation has three distinct modes: acceleration, servo lock, and deceleration. During acceleration, the servo loop is closed but not locked to the reference frequency. To avoid excessive stress on the tape, motor, and power supplies, the loop gain is reduced. Once acceleration is complete, the loop has locked to the reference. At this point the bandwidth of the loop is increased by increasing the gain of the servo system. The high-gain condition is sustained until deceleration begins. During deceleration the low-gain condition is in effect. The loop is no longer closed because it would be impractical to attempt to lock to 0 Hz.

In steady state operation long term ($\geq$0.1 s) speed variations are less than $\pm$2%.

The read/write system uses a dual track, center-tapped magnetic head for data transfer. The general block diagram is shown in Fig. 6.

Magnetic recording is accomplished by driving the center taps of the dual track head with a current source and by alternately grounding the remaining two head lines of the appropriate track under microprocessor control. As the current is allowed to flow from one winding to another, the magnetic field polarity is reversed and a flux reversal is recorded on the moving tape. The current source remains off during power-up and power-down sequences and when a write command is not in effect.

During a read operation, the flux distribution on the tape induces an output voltage across the head windings that is proportional to the time derivative of the magnetic flux. The voltage signal appears as a train of positive and negative pulses.

Analog switches gate the selected track to the preamplifier inputs. The preamp is configured differentially to maximize common-mode rejection. The second stage amplifier provides additional gain and acts as a low-pass filter to reduce spurious high-frequency interference. To block the dc offset of previous stages and to attenuate low-frequency noise, the read signal is ac-coupled into a band-limited integrator. The integrator also attenuates high-frequency noise.

The integrator output is injected into the compara-

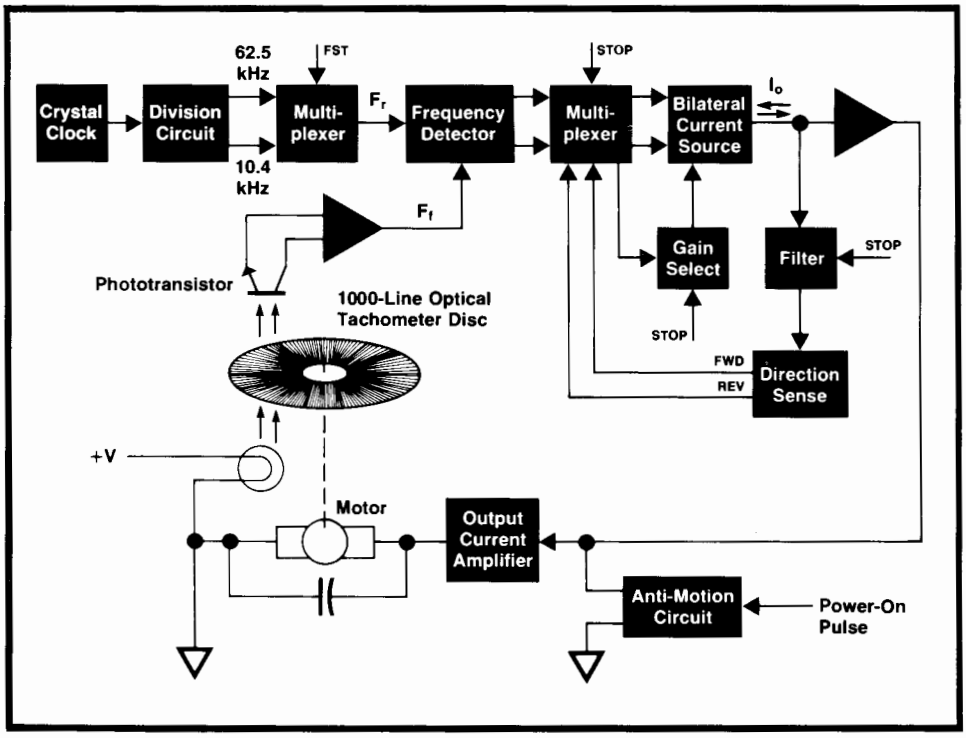


Fig. 5. *Cartridge tape speed control system is a frequency-locked loop that uses an optical tachometer for sensing motor speed.*

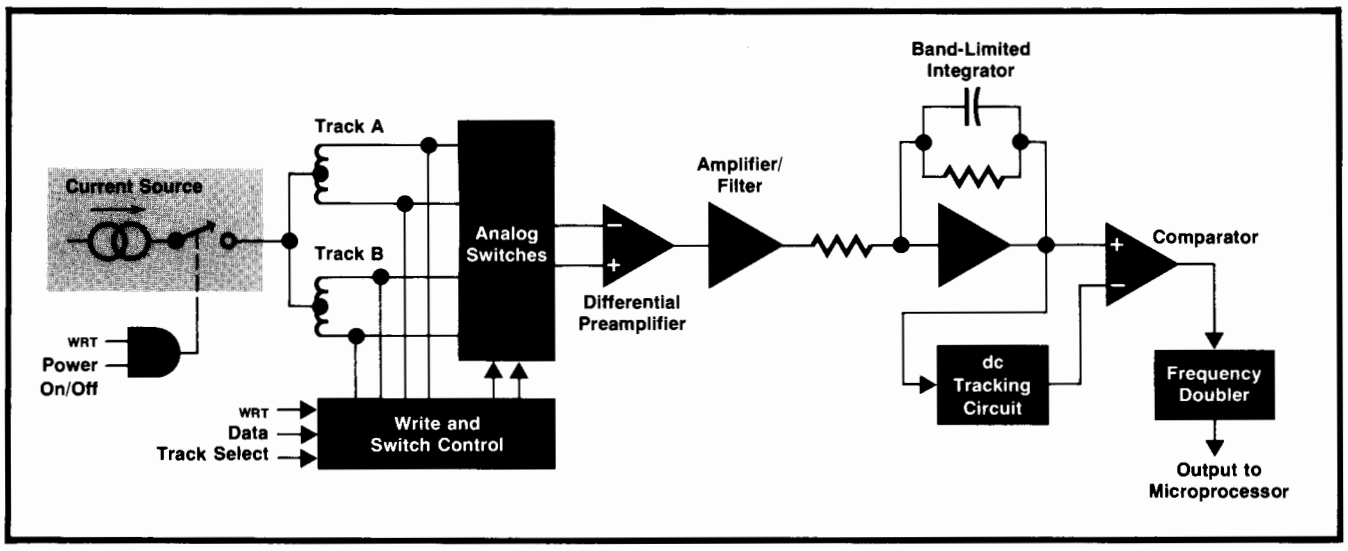


Fig. 6. *9815A cartridge tape read/write system. Data decoding is done by firmware. The 9825A Calculator has the same write system, but decoding is done by hardware.*

tor stage, which functions as a "relative" zero crossing switch. The rising and falling edges of the comparator output are coincident with the voltage peaks (flux reversals) from the magnetic head. The frequency doubler translates the peaks to rising edges only. Its output is sent to the microprocessor for interpretation and bit reconstruction.

Power Supply and Packaging

One of the biggest challenges of the entire project was putting all the pieces together in one small box. The power dissipation was of concern also as components were placed in close proximity inside the case. A goal of only 10°C temperature rise inside the case was set early in the project and was met. Because of these constraints, the power supply needed to be more efficient than normal series pass supplies, so a switching supply was designed to provide the +5V power.

The noise of the switching supply proved to be a formidable problem in the layout of the printed circuit boards. Much care was spent on shielding critical lines and busing the power traces on the boards. A star grounding and power busing technique was used to keep noisy signals from affecting critical low-level signals, such as the signals from the tape system.

The machine has only three main circuit boards. With much effort spent in printed circuit layout, the designers were able to keep from using multilayer boards and saved a significant amount in the costs of these assemblies.

One board contains the main processor electronics. This includes the microprocessor and I/O chips, the seven ROMs, and the six RAMs. A number of discrete ICs used for chip select and address decoding are also included on this board.

Another board has the electronics for the internal peripherals. The display electronics and the keyboard scanning are done on this assembly. Part of the tape system electronics is also here.

The third board is the power supply board. Included with the power supply board are most of the tape and printer electronics. A separate power module houses the transformer and main power transistors.

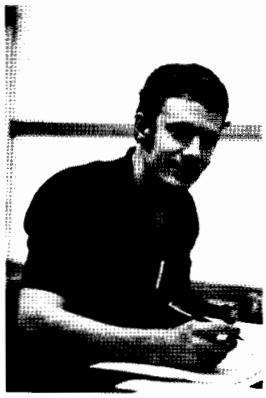
The case is made of injection molded plastic. The electronics are packaged as a sandwich and connected to the keyboard panel. The power supply assembly attaches to the base of the case along with the printer and tape transport. Because of the imaginative use of plastic hinges and interlocking case parts, only six screws are needed to hold the case together. The calculator weighs only 13 pounds and takes up a little more than a square foot of surface area.

Douglas M. Clifford

Doug Clifford came to HP in 1968 and designed microwave spectrum analyzers for three years before joining HP's Calculator Products Division. He was responsible for the HP-46 and HP-81 Calculators and was project manager for the 9815A Calculator. He holds several calculator-related patents. Doug received his BSEE degree from Brigham Young University in 1968 and his MSEE from Stanford University in 1970, and expects to complete his work for the MBA degree at Colorado State University this year. An active participant in his church, the Boy Scouts, and the national ski patrol, Doug is married, has four children, and likes to ride motorcycles and horses and play golf, basketball, and volleyball. He was born in Safford, Arizona and now lives in Loveland, Colorado.

A. Craig Mortensen

Craig Mortensen received his BSEE and MSEE degrees from Brigham Young University in 1972 and 1973, then joined HP to work on the 9815A Calculator. He's authored two patent applications as a result of his servo and read/write electronics design for the 9815A cartridge tape system. Craig was born in St. Anthony, Idaho, and now lives in Loveland, Colorado. He's single, and enjoys all outdoor sports and activities, especially skiing. He's a student of karate and is active in his church.



F. Timothy Hickenlooper

Tim Hickenlooper helped design the I/O system and mainframe firmware of the 9815A Calculator. With HP since 1974, when he received his BSEE degree from Brigham Young University, Tim is now a production engineer at HP's Calculator Products Division. A native of Provo, Utah, he's married, has two young children, and lives in Loveland, Colorado. He's active in his church and as a Boy Scout leader, he enjoys sports, especially basketball and volleyball, and he likes to work on cars and invent electronic devices.

SPECIFICATIONS

HP Model 9825A Calculator

INTERNAL STORAGE (READ/WRITE MEMORY)

Standard	6,844 bytes
Opt. 001	15,036 bytes
Opt. 002	23,228 bytes
Opt. 003	31,420 bytes

DYNAMIC RANGE: 10^{99} to 10^{-99}, 0, -10^{-99} to -10^{99}

INTERNAL CALCULATION RANGE: 10^{511} to 10^{-511}, 0, -10^{-511} to -10^{511}

SIGNIFICANT DIGITS: all numbers are calculated and stored internally with 12 significant digits, regardless of the format used.

ADDRESSING MODES: Conditional and unconditional for absolute, relative, symbolic, and computed.

SPECIAL FUNCTION KEYS: 12, shiftable to 24

TAPE CARTRIDGE

Capacity:	250,000 bytes
Average Access Time:	6 sec
Read/Write Speed:	559 mm/sec (22 in/sec)
Search Speed: (bidirectional)	2,286 mm/sec (90 in/sec)
Transfer Rate:	2,750 bytes/sec
Typical Access Rate:	14,300 bytes/sec
Rewind Time:	19 sec (end to end)
Typical Erase Time:	40 sec (one entire track)
Cartridge Size:	63.5 mm × 82.5 mm × 12.7 mm (2.5 in × 3.25 in × 0.5 in)
Verification:	Automatic on recording

PRINTER

Paper Width:	57.15 mm (2.25 in)
Speed:	190 lines/min
Font:	A 5 × 7 dot matrix. Prints all the characters shown below in upper and lower case. Up to 16 characters/line.

DISPLAY: the standard 32-character LED display displays all of the following characters:

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz[]↑←_@
0123456789:;<=>?!"#$%&'()*+,-./↑
```

With the String or General I/O ROM, the following characters are available:

```
ÄäÅåÖöÜüÉéÑñ¿¡ßΓδΔΘλμσΣτΦΩ
¤£¥|→←↓↑▒
```

PERIPHERAL I/O

CAPACITY: Three general I/O slots

TRANSFER RATES: Input rate of up to 400k transfers/sec, output rate of up to 200k transfers/sec depending on the program, ROMs used, and I/O card. (A transfer is one 16-bit word or one 8-bit byte.)

INTERFACE: Dedicated card and cable assemblies for peripherals, plus general I/O interface cards providing HP-IB, bit-parallel, and BCD formats. HP-IB format conforms to IEEE Standard 488-1975.

ENVIRONMENTAL RANGE

OPERATING TEMPERATURE: 5°C to 40°C ambient

STORAGE TEMPERATURE: −40°C to +65°C

AMBIENT HUMIDITY: <80%

SIZE/WEIGHT

HEIGHT: 129.5 mm (5.1 in)

WIDTH: 383.5 mm (15.1 in)

DEPTH: 495.3 mm (19.5 in)

NET WEIGHT: 11.8 kg (26 lbs)

POWER REQUIREMENT

SOURCE: 100/120/220/240V +5%, −10%

LINE FREQUENCY: 48 to 66 Hz

POWER CONSUMPTION: 100V/1.7A
120V/1.5A
220V/.8A
240V/.75A

INTERFACES

Interface Card	Card Number
16-bit Duplex	HP 98032A
BCD	HP 98033A
HP-IB	HP 98034A

ADD-ON ROMs

STRING-ADVANCED PROGRAMMING: Single strings and string arrays. String size limited by memory size. Seven string functions and one string operator. Parameter-passing functions and subroutines with local variables. FOR-NEXT statements and cross-reference operator. Split and integer precision number storage.

MATRIX: Performs matrix addition, subtraction, multiplication, transposition, and inversion. Performs addition, subtraction, multiplication, division, initialization and redimensioning on n-dimensional arrays. Prints arrays on the strip printer.

9862A PLOTTER-GENERAL I/O: HP 9862A Plotter statements for scaling, plotting, labeling, and drawing axes.

GENERAL I/O: Basic I/O capabilities including read/write with format control. Lists programs on a peripheral. Status testing. Compatible with HP-IB peripherals.

EXTENDED I/O: Complete HP-IB control. Interrupt commands. Auto start, error trapping, and time out. Bit manipulation and testing. Code conversion, burst read and write, buffered I/O, and direct memory access (DMA).

ORDERING INFORMATION

OPTION NO.	KIT NO.	DESCRIPTION
Standard HP 9825A		6,844 bytes of memory, 32-character LED display, 16-character strip printer.
Opt. 001		15,036 total bytes of memory
Opt. 002		23,228 total bytes of memory
Opt. 003*		31,420 total bytes of memory
	98221F	Field installed 8,192 bytes of memory
	98222F	Field installed 16,384 bytes of memory
Plug-In ROMs	98210A†	String—Advanced Programming
	98211A	Matrix
	98212A	9862A Plotter—General I/O
	98213A†	General I/O—Extended I/O
	98214A†	9862A Plotter—General I/O—Extended I/O

*Will not operate with ROMs 98210A, 98213A, and 98214A.

†Will not operate with 31,420 bytes memory.

PRICE IN U.S.A.: 9825A Base Price, $5900.

HP Model 9871A Printer

SPEED

Average text line of 10 characters/in: 30 characters/sec. Best case of 10 characters/in, no rotation: 32 characters/sec. Worst case of 10 characters/in, 180° rotation: 14 characters/sec.

Carrier return or tab, full length: 325 msec.

Line feed, 0.167 in. (4,23 mm): 50 msec.

PAPER

Single sheet or continuous feed. Form feed mechanism recommended for continuous feed.

Single part or multi-part, 2 to 6 parts.

15 in (381 mm) maximum width.

DIMENSIONS

HEIGHT: 19 mm (7.75 in.)

WIDTH: 565 mm (22.25 in.)

DEPTH: 387 mm (15.25 in.)

WEIGHT: 18.4 kg (40.5 lbs)

SHIPPING WEIGHT: 24.5 kg (54 lbs)

POWER REQUIRED

SOURCE: 100/120/220/240V +5%, −10%

FREQUENCY: 48-66 Hz

CONSUMPTION: 200VA maximum (printing)
60VA (nonprinting)

ENVIRONMENTAL RANGE

TEMPERATURE: 0° to 45°C

HUMIDITY: 5% to 95% RH (noncondensing)

OPERATING CONTROLS

Power on-off switch

Self-test, pushbutton switch

9-position print intensity adjustment

Safety interlock (stops printing when access cover is removed)

BUFFER

158 characters—automatically fills if characters are received faster than print rate. Status line indicates when 16 characters are left in buffer. The buffer may also be used for storing tab information and user defined characters.

EXTERNALLY PROGRAMMABLE FUNCTIONS

96 printing characters, self test, horizontal tabs, vertical tabs, dot and line plotting, character and line spacing, bell.

ORDERING INFORMATION

One of the following interface options is required:

Opt. 010 for use with the HP 9810A—Opt. 010 requires either the HP 11252A or HP 11264A Peripheral Control ROM's or HP 11262A Peripheral/Cassette ROM or HP 11266A Peripheral/Printer Alpha ROM.

Opt. 020 for use with the HP 9820A.

Opt. 021 for use with the HP 9821A—Opt. 020 and 021 require either the HP 11220A or the HP 11224A Peripheral Control ROMs. The HP 11221A Math ROM is required for plotting and form filling.

Opt. 030 for use with the HP 9830A.

Opt. 015 for use with the HP 9815A.

Opt. 800—European Print Disc.

Opt. 801—ASCII Print Disc.

PRICE IN U.S.A.: 9871A, $3400.

HP Model 9815A Calculator

STORAGE

DYNAMIC RANGE: 10^{99} to 10^{-99}, 0, -10^{-99} to -10^{99}

R/W MEMORY: 472 program steps, 10 data registers**

OPT. 001: 2008 total program steps, 10 data registers**

**May be allocated by user into any combination of program steps and data registers

DATA CARTRIDGE: 96,384 bytes (8 steps = 1 register, 1 step = one 8-bit byte), 12,048 registers

SEARCH SPEED: 1524 mm/sec (60 in/sec) bidirectional

R/W SPEED: 254 mm/sec (10 in/sec)

TAPE LENGTH: 42.67 m (140 ft)

FILE SIZE: 80 bytes to 2008 bytes, programmable

DIMENSIONS: 63.5 × 82.5 × 12.7 mm (2.5 × 3.25 × 0.5 in)

THERMAL PRINTER

PAPER: 55 mm (2.25) in wide

PRINT: 5 × 7 dot matrix, 16-character line

NO. OF DIGITS: 10 digits maximum, plus sign and signed 2-digit exponent. Print format user selectable.

AVAILABLE ALPHA:

ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789 ÜÜÄÄ£ÑÆ
(),;:+−*/=%#?$@'&α⟩÷→π↓⟨>

DISPLAY

TYPE: 7-segment gas discharge

SIZE: 16 numeric characters; 10 digits maximum with a signed 2-digit exponent.

NOTATION: Fixed, scientific, scientific 3

ENVIRONMENTAL RANGE

TEMPERATURE: 5°C to 40°C ambient

HUMIDITY: 80%

SIZE/WEIGHT

HEIGHT: 101,6 mm (4 in)

WIDTH: 345,4 mm (13.6 in)

DEPTH: 342,9 mm (13.5 in)

WEIGHT: 5,9 kg (13 lb)

SHIPPING WEIGHT: 11,8 kg (26 lb)

POWER REQUIREMENT

SOURCE: 100/120/200/240V +5%, −10%

FREQUENCY: 48 to 66 Hz

CONSUMPTION: 100V/850mA
120V/725mA
220V/400mA
240V/350mA

ORDERING INFORMATION

STANDARD-HP 9815 with 472 program steps, 10 data registers

OPT. 001: 2008 total program steps

OPT. 002: 2 I/O channels

PRICE IN U.S.A.: 9815A Base Price, $2900.

MANUFACTURING DIVISION: CALCULATOR PRODUCTS DIVISION
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Loveland, Colorado 80537 U.S.A.

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