Bernard E. Musch

Bernie Musch's HP career parallels the history of HP personal calculators. He joined the company in 1970 and helped design the HP-35, the first HP handheld calculator. He contributed to the HP-55 and HP-65, served as project manager for the HP-91, and since 1976 has been section manager for various handheld calculators including the HP-41C. He's authored several papers, most recently on the calculator business, and generated several patents in the areas of mechanical design and calculators. He received his BSME degree from Lehigh University in 1964 and his MSME and PhD degrees from Stanford University in 1966 and 1970. Born in Baltimore, Maryland, Bernie is married, has two sons, and lives in Corvallis, Oregon. He's interested in music and sports, is active in the American Youth Soccer Association, and serves as scoutmaster of the local Boy Scout troop.

John J. Wong

Mainland China is the birthplace of John Wong, who came to California in 1963 and to Hewlett-Packard ten years later, following his graduation from the University of California at Berkeley with a BS degree in electrical engineering. John developed several integrated circuits for the HP-25, HP-25C, and HP-27 Calculators before becoming project leader for the HP-41C. He later took over responsibility for all of the HP-41C electronics as project manager. John, who lives with his wife and two children in Corvallis, Oregon, spends his spare time doing electronics projects at home and exploring his interest in photography and hi-fi stereo.

David R. Conklin

Dave Conklin started his career with HP in 1975, then resigned to move to Corvallis, Oregon, only to join HP again when the calculator division moved to that city. While with HP's Santa Clara Division, he was a quality assurance systems engineer and a programmer on the 5420A Digital Signal Analyzer. At the Corvallis Division, he first worked with the firmware team for the HP-41C, then became project manager for the 41C follow-ons in 1979. Dave's BA degree in mathematics is from the University of California at Berkeley (1967), and his MS degree in computer science was completed in 1975 at the University of Santa Clara. Dave has also worked in programming and systems analysis for nuclear power plants and computer-controlled sawmill systems. A member of ACM and IEEE, Dave is married and lives in Corvallis. Raising mules and applying programmable calculators to problems in pharmacokinetics are among his leisure time activities.

was the guiding spirit of the HP-41C firmware. Other members of the firmware team were Steve Chou, Gaye Daniels, Ray Davis, Greg Filz, Bob Worsley, and Dennis York. The math algorithms were adapted for the HP-41C by Dennis Harms and Tony Ridolfo. Ed Liljenwall was the industrial designer. Roger Quick managed the project single-handedly in its early stages. Special thanks must go to Max Schuller, whose experienced hand stabilized our course during the final push into production. Bernard Tsai was and is our production engineer. Ray Tanner wrote the HP-41C manual. In addition, there were many individuals outside the product development team without whose able assistance we could not have succeeded.

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Card Reader Offers Compatibility and Expanded Capability

by David J. Lowe and Patrick V. Boyd

MODEL 82104A CARD READER, an accessory to the HP-41C Calculator, is an adaptation of the card reader design used in the HP-65, 67, and 97.[1,2] This design has proved effective and provides compatibility between the HP-41C and the HP-67/97. Thus the large software library of HP-67/97 programs is a great asset for the HP-41C.

A basic consideration in the 82104A design was that the

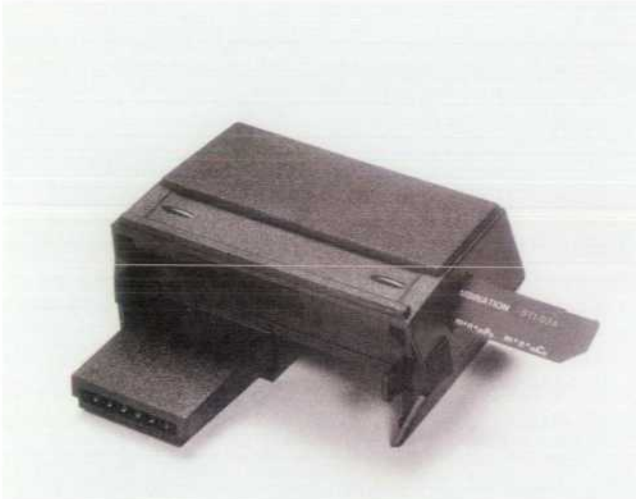

Fig. 1. *Model 82104A Card Reader plugs into the HP-41C. It will read HP-67/97 magnetic cards as well as HP-41C cards.*

card reader be small enough to plug onto the HP-41C and become an extension of its package, simulating the built-in card reader of the earlier calculators but having the flexibility of an accessory that can be purchased separately and removed at will (see Fig. 1).

HP-67/97 Compatibility

The new card reader will read cards written on an HP-67 or 97 but an HP-67/97 will not read cards written on the 82104A. When the 82104A is plugged into the HP-41C it adds several new functions to the function library of the HP-41C, much as new functions are added by plugging in application modules. Among the card reader functions is the translation routine used to convert HP-67/97 cards. This routine is transparent to the user and cannot be executed from the keyboard. It is automatically executed when an HP-67/97 card is inserted.

The first information read from a card allows the calculator to decide how to process the rest of the data on the card. In the case of an HP-67/97 card the translation routine is executed. Not every HP-67/97 function has a corresponding HP-41C function and vice versa. When an HP-67/97 function and an HP-41C function are close enough the translation routine modifies the HP-67/97 function to make it an HP-41C function. An example is the HP-67/97 function X≤I. In the HP-41C there is no register designated I. Any register can be used as an indirect register. When the translation routine comes across an X≤I it replaces the I with register 25, which can be used as an indirect register. Because the translation routine automatically makes these changes it may be necessary to change the user instructions of some HP-67/97 programs. User instruction changes for HP-67/97 application pacs are outlined in an appendix of the 82104A Owner's Handbook.

In some cases neither a direct translation or a modification would allow an HP-67/97 function to be converted to an HP-41C function. An example is display formatting. On an HP-67/97 you specify the type of display: fixed decimal point, engineering, or scientific notation. Then in a separate process you specify the number of significant digits or digits after the decimal point. On an HP-41C you specify both the type of display and the number of digits in the same set of keystrokes. It was necessary, therefore, to allow for HP-67/97 programs adjusting the significant digit count without changing the display type. This was done by adding these functions to those in the HP-41C mainframe. Whenever you plug an 82104A into an HP-41C you add a new set of functions that are direct implementations of HP-67/97 functions that could not otherwise be translated.

Hardware Improvements

In the process of adapting the HP-65/67/97 card reader design to the HP-41C an effort was made to improve on as many features of the design as possible. One of these improvements involved the switches that detect the position of the card as it passes through the card chamber. In the old design, space was at a premium, forcing the switches to make very little movement in going from open to closed position. The switches had to be carefully adjusted as they were installed in the factory. The 82104A overcomes this problem of switch adjustment with a new switch design that uses buckling columns instead of cantilever beams (Fig. 2). The actuating motion of the switches is greatly increased, making adjustments unnecessary. The switches are independent (separate) to avoid the coupling problem of the earlier design, which incorporated all the switches in the same piece of metal.

The requirement that any 82104A plug into any HP-41C dictated another improvement, this one in the control of the motor speed. The subtle differences in HP-41Cs make it mandatory that the card reader itself maintain tight tolerances. Where the previous motor speed control was open-loop, the new design closes the loop, providing feedback control. The principle is the same as that used to control the motor speed accurately in the printer of the HP-97. The motor is driven with a pulse train, and the pulse duty cycle is varied by the feedback loop, maintaining constant speed even when the load on the motor varies.

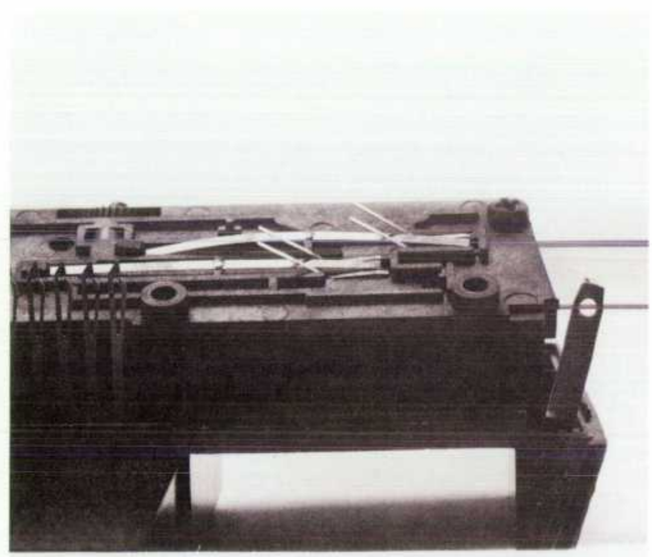

Fig. 2. *A new card-detection switch design eliminates critical adjustments.*

Minimizing Power

Power consumption was a major consideration. While the HP-41C uses very little power, the card reader with its motor and circuitry to drive the magnetic head consumes large amounts of power. To cut power consumption to a minimum, the circuits that uses the most power are powered only when a card is in the card chamber. The switch that indicates the presence of a card is also a power switch. Thus, the time that the card reader is drawing energy from the batteries is measured in seconds instead of weeks.

Besides the problem of average power, there is the problem of peak power, such as the power surges required to start the motor. Accommodating these peak drains on the battery required the isolation of all circuits that were sensitive to dips in battery voltage.

Low-Battery Software Control

To further extend card reader usability with a set of old batteries, software controls power use by pulsing the motor. When the batteries approach the low-battery state, software begins to turn off the motor for short periods of time to lower the motor duty cycle and decrease power consumption, giving the batteries more time to recover between pulses. As the battery voltage drops lower and lower the motor off time increases. Even though the motor is being turned off for short periods as the card goes through, it is easily possible to have a correct read, and the difference may even be imperceptible to the user. The 82104A verifies a good read on every card by computing a checksum during each card pass and comparing it to the sum recorded in the last 28 bits of information on the data track. To tell the user what is happening, the message LOW BAT is displayed at the end of any read in which the motor has been turned off, whether the read was good or bad. Many good reads may be possible when the batteries are in this condition.

Because there is no way for the calculator to check to make certain that the information it tried to write on a card got recorded correctly, there is a chance that bad or incomplete information could be written when the motor is pulsed under a low-battery condition. To be safe, therefore, the calculator aborts a write session as soon as it is discovered that the batteries may be too low to complete the write under normal conditions.

Writing consumes more power than reading. Because of the internal impedance of the batteries, they appear to be at a lower voltage during a write than during a read. This means that, even though there is not enough energy in the batteries to finish a write operation, there may still be enough for several more successful reads. Internal impedance of the batteries also accounts for the ability of the calculator to operate well after the batteries have discharged below the point where they will operate the card reader.

New Functions

Several new functions have been added to the 82104A to make it more powerful and useful than its predecessors. Programs may be executed automatically as they are read in. If Flag 11 is set when a program is recorded on a card, that program is marked for automatic execution. Thereafter, each time the program is read in, it will begin to execute as soon as the read is completed.

Data cards will hold 16 registers per side, or 32 per card. The data may be taken from or returned to any portion of data memory, as directed from the X register (display) with the WDTAX and RDTAX functions.

The status of flags and key assignments of the HP-41C can be preserved using the WSTS function. The flags are recorded on the first card side, and key assignments are recorded on subsequent sides as necessary. The display prompts the user for the appropriate number of cards using the format RDY kk of nn, where nn is the total number of card passes (tracks) required to complete the sequence and kk is the lowest unread track number (a track is one side of a card). The prompt is displayed in both read and write sequences. Write sequences can be aborted at any time without memory loss. RSTS can be aborted after the first (flags only) card pass without penalty. If desired, all RAM registers (80 in the mainframe, 64 per module) may be dumped onto cards using the WALL function.

Cards are protected from accidental overwriting by the traditional corner clip. However, protected cards may be overwritten by setting Flag 14 (SF14) before initiating a write sequence. The flag is automatically cleared if the sequence is either completed or aborted.

Cards can be verified for proper data and identification by executing the VER function. Each card will be identified as to type (HP-67, status, program, data, WALL) and track number (1-15), and the checksum verified to insure that a proper write has taken place. VER does not alter any status,

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Patrick V. Boyd

Pat Boyd was born in Reedsport, Oregon and attended Oregon State University, graduating in 1973 with a BSME degree. After three years doing mechanical design of tractor winches and forklift trucks, he joined HP in 1976 and contributed to the mechanical design of the card reader for the HP-41C Calculator. He's a member of ASME and a registered professional engineer in the State of Oregon. Having recently left HP's Corvallis Division, Pat now lives in Battle Creek, Michigan. He's married and has a son and a daughter, and if his children take up most of his spare time, that's just fine with Pat, who thinks that "nothing else gives such a large return on investment" as keeping a couple of children "healthy, happy and growing straight."

data, or programs in the calculator. The check that is made is the same as that made during a read. By using VER, it is possible to insure that a card will read in properly without disturbing the calculator.

Acknowledgments

Special thanks go to Dennis York and Steve Chou for their help with this article. Dennis was responsible for the software translation routines that give the 82104A compatibility with the HP-67/97 card readers. Steve's responsibility was the software for the remaining routines. These include the functions the user accesses during card reader use. Others involved in the design of the 82104A were Tom Peterson, who worked on the case design, George Custer, who helped keep us organized in the final stages of the design, Bill Buskirk, who assisted in the electrical designs, and Bond Ying, who assisted with the CMOS ICs. Charlie Allen was the industrial designer. Recognition should also be given to the numerous support people who made it possible to get this product into production.

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Evolutionary Printer Provides Significantly Better Performance

by Roger D. Quick and Donald L. Morris

PRINTED OUTPUT is a highly desirable adjunct to a programmable scientific calculator. As computing power, program length, data capacity, and communication ability all increase, a printed record becomes a necessity for many users of such calculators.

As the power of the calculator increases, so must the abilities of the corresponding printer. To give the user maximum flexibility, a peripheral printer was chosen for the HP-41C. This separation gives the user the portability of a handheld calculator and also maintains briefcase portability for the calculator/printer system. The new printer, Model 82143A, Fig. 1, contains its own rechargeable batteries, and measures 18 × 13 × 6 cm.

With earlier HP programmable printing calculators, such as the HP-97,[1] the printer was able to record numbers, listings of programs, and the trace of an executing program. The 82143A Printer makes these records and more. It can label numeric output with meaningful words and phrases, has access to 127 standard characters, makes normal and condensed program listings, can create its own characters, and gives the HP-41C user a graphics capability through the printer's plotting functions. Thus the 82143A adds functional capabilities to the HP-41C system in addition to its normal printed record function.

The 82143A printer is similar to other HP-41C accessories in that the mainframe calculator is not burdened, either in ROM space or in execution time, by the existence of accessories. When the printer is plugged in, firmware in ROM is added to the HP-41C system bus. This additional system ROM is contained in the 82143A module that plugs into the HP-41C. Thus connected, the printer adds 24 functions to the mainframe's repertoire, and has access to all capabilities of the mainframe. This closely linked architecture makes it possible for the HP-41C to display printer error messages, to treat the PRINT key on the printer as if that key were on the HP-41C keyboard, and to have HP-41C functions such as AVIEW print whenever there is an operational printer attached. These friendly capabilities give the HP-41C/82143A system attributes similar to a package-integrated system like the HP-97 without assuming that all users want all the pieces all the time.

Printer Features

The printer has its own power light and a low-battery light. A portion of the printer ROM is under calculator processor control, allowing the HP-41C Calculator display to be used to output printer messages, such as OUT OF PAPER or PRINTER OFF when an attempt is made to execute a printer function under such conditions. The printer also has a five-position print intensity control switch that allows the user to adjust the print density by direct control of the voltage applied to the printhead.

The new printer is much faster than earlier designs. The improvement was accomplished by means of an encoder feedback loop, a sophisticated printhead drive, and a soft printing platen behind the paper. Also, a significant improvement in program listing speed was obtained by giving the user the choice of three program listing formats.

Program listings can be generated by the functions PRP and LIST. PRP prints the whole program and LIST prints only the specified part of a program. Both PRP and LIST can generate all three formats: left justified, right justified (which is faster and allows labels to be found more easily), and a condensed format that prints several program steps