The Hewlett-Packard Interface Loop—HPIL

Unique Two-Wire System Allows Low-Cost Data Collection

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The most intriguing feature of the Hewlett-Packard HP-41C has been the multiple plug-in port on the unit's back (see Steve Leibson's *"The Input/Output Primer, Part 3,"* page 186). Until now, four ports have been available for plug-in RAMs, ROMs, a card reader, a thermal printer, and a bar-code reader. Yet users have been begging for the chance to let the HP-41C talk to the outside world. Hewlett-Packard is very protective of its products and does not publish specifications of the connections to these ports. Justifiably, because the calculator's delicate CMOS (complementary metal-oxide semiconductor) circuitry can be damaged easily by improper connections.

The public demands and Hewlett-Packard responds. By announcing the Hewlett-Packard Interface Loop (HP-IL), Hewlett-Packard has provided users with much more than they've been requesting. The HP-41C was a quantum leap beyond conventional calculators, and, remarkably, the HPIL is a quantum leap for the HP-41C.

The Loop Hardware

HPIL operation is powerful and sophisticated, but the hardware is simple, small, and easy to interconnect. A board called the HPIL Module (HP82160A) plugs into any of the four ports on the back of the HP-41C. The module receives its power from the HHC's internal batteries. Two 71-cm (28-inch), 2-wire cables extend from the module; at their ends are 2-pin male and female con-

About the Author
Robert Katz, who prefers to be called "Bob," is a recording engineer for records, TV, and radio. He also dabbles in computers.

At a Glance

Name
Hewlett-Packard Interface Loop (HPIL)

Manufacturer
Hewlett-Packard
1000 Northeast Circle Blvd.
Corvallis, OR 97330

Price
HP82160A HPIL Module: $125, available now; *HP82183 Extended I/O ROM*: price to be announced, available summer 1982; HP82180A Extended Functions/Memory Module: $75, available now; HP82181A Extended Memory Module: $75, available now; HP82166 HPIL Converter: $395 for a prototyping kit including 2 converters, test board, HPIL cables and manual, or $1250 in quantities of 10 with no accessories, available spring 1982; HP82182A Time Module: $75, available mid-1982; HP82161A Digital Cassette Drive: $550, available now; HP82162A Thermal Printer/Plotter: $495, available now; HP3468A Programmable Digital Multimeter: $695 plus $125 for battery option, available now; HP82938A HPIL Interface Card for HP Series 80 Personal Computers: $295, available now;

Description
HPIL is a complete software and hardware system that turns the HP-41C handheld computer/calculator into a general-purpose, data collection, measurement, and analysis tool as well as an equipment controller.

Other features
Simple 2-wire connectors, "transparent" operating system

Hardware options
Digital Data Cassette, Thermal Printer/Plotter, Programmable Multimeter, GPIO Interface, Computer Interface, among others

Audience
Original equipment manufacturers (computer-aided manufacturing), instrumentation manufacturers, hobbyists, others

A Day in the Life of an HP-41C

I prefer to call my HP-41C an HHC. That way I don't have to call it a "calculator" or a "computer." Hewlett-Packard calls it both a "calculator" and a "system." Actually, the versatile HP-41C can be treated any way the user desires. Its power and flexibility are illustrated by the following tour of the HP-41C world.

It's morning and I find no cash in my pockets. No, the HP-41C cannot mint money, but its continuous memory can tell me how much I have in my checking account. Upon pushing RCL *(recall), the legend* RCL *appears in the alphanumeric liquid-crystal display. To the right, two* prompts *(cursors) can be seen; these prompts are the HHC's signal to supply a two-digit number in response. Since data register 9 contains the amount of my checking account balance, I punch* 0 *and* 9*. The HP-41C answers with $127.59000.*

I only need to display two digits after the decimal, so I push SHIFT *for secondary key functions, then* FIX *and* 2*. Each key gives a satisfying "thunk" when pressed; tactile feedback has always been a Hewlett-Packard feature. The display is even more helpful by naming each button's function as it is pushed. It's also easy to cancel or correct a function if a mistake is made. By using the back arrow key ←, the screen unambiguously shows each correction, and HP-41C error messages appear in English.*

I see that I have exactly $127.59 in my checking account. Before deciding to deplete the account, I run downstairs to check the just-delivered mail and happily discover the arrival of a check for $300. Pushing 3 0 0 STO + 0 9 *adds the $300 to my checking account (at least within the calculator). In addition, I push* Σ+ *and see the number 12, marking the twelfth deposit I have made since I began to count deposits in the Sigma registers. The Sigma registers can compute the mean (average) of all my deposits, the standard deviation, and other statistical functions. To find the mean, I push* XEQ *(for* execute *or* run*) and then spell out* M-E-A-N. *This ability to call a function by spelling out its name is very much a computer-like action.*

After stopping at the bank, I head for the recording studio where I work as an acoustical consultant and maintenance man. Arriving at the studio, I discover a volume unit (VU) meter that reads too low. I apply a sine wave to the recording console's input; 2.0 volts (V) are measured across the output terminals, yet the meter reads 0 VU. Thanks to a program I've written, my HP-41C can talk to me in English and clue me in to the decibel error of the meter (see listings 1 and 2). I can call this program in two ways. One way is by name as above: XEQ d-B-V, and the program begins running. Since I use the dBV program a lot, I reduced the keystrokes to a single one via the USER mode.

In USER mode, the HP-41C is customized for individual use; programs or functions can be reassigned to any keys. The entire keyboard can even be reconfigured if desired, then returned to normal by a second push of the USER *key. An added attraction is a keyboard overlay which allows you to identify reassigned keys with stick-on labels. Thus, a small, uncluttered keyboard can call literally hundreds of functions.*

Throughout the course of the morning, I will use several HP-41C functions and two other programs. When the job is done, I attach the HP-41C to one of many available accessories, a battery-powered thermal printer. With the aid of still another program, it prints out an invoice of parts and labor performed on this job.

On the way to the next job, a friend and I play a game of Hangman on the HP-41C. This game is included in the Games Pac, which is designed to help while away those between-business hours. More serious Standard Module Pacs are available to help perform engineering and scientific tasks, among others. The average application module price is $35. The COPY function permits copying any program from ROM (read-only memory) to RAM (random-access read/write memory) to allow customizing. For example, I have added personalized prompts to the game of Hangman.

Listing 1: A single key depression in USER mode executes the author's program dBV. The calculator first prompts for a voltage entry; response is 2.0 V, and the RUN key is pressed. The calculator asks for reference voltage; 0.775 V is assumed if RUN is pressed. The answer is 8.2 dB over 0.775-V reference. Next, the program is run with a different reference voltage (1.23 V, which is 4 dB above a one-milliwatt reference across 600 ohms). The answer is 4.2 dB over 1.23 V. Another key depression in USER mode executes the author's program VOLTS. The calculator indicates that 1.55 V is 6 dB over 0.775 V. The display is formatted to two decimal places but can easily be changed.

```
     XEQ  "dBV"
VOLTS?
  2.0      RUN
REF?R/S=STND
           RUN
8.2 dB/0.8 V
    XEQ  "dBV"
VOLTS?
  2.0      RUN
REF?R/S=STND
 1.23      RUN
4.2 dB/1.2 V
 XEQ  "VOLTS"
dB?
 6.00      RUN
REF?R/S=STND
           RUN
1.55 V/0.77
```

The powerful programming ability of the HP-41C is enabled by an extended version of the RPN language that Hewlett-Packard introduced to the public in 1971 with the world's first handheld scientific calculator, the HP-35. Over 130 scientific functions and 56 programmable flags are available, some of which keep track of the status of peripheral devices as well as control the peripheral's status. While all previously made calculators were hardware-intensive *devices, the HP-41C is a* software-intensive *device. As such, each plug-in module adds completely new functions, giving the HHC a new personality.*

Hewlett-Packard has taken a lot of care in naming functions so one can remember them easily, but if I forget the name of a function and don't have the instruction manual handy, I'm not helpless. I can call up a CATALOG, a directory of the many functions available. Three such catalogs exist in the HP-41C (see listing 3). Usually this list is enough to jog my memory.

The future of the HP-41C is virtually unlimited. If there were enough demand, a higher-level language such as FORTH or even BASIC could be implemented in a plug-in ROM. However, I find that the versatility of RPN eliminates the need of a higher-level language in most applications. A BASIC interpreter would run markedly slower than RPN. FORTH might be faster than BASIC, but the experienced user soon discovers that new functions can be added in a remarkably FORTH-like manner.

Listing 2: A single key depression in USER mode executes the author's program PTOF (pitch to frequency). The calculator asks for the note, and the operator responds with "B Flat," one octave below middle C. The answer is 223 Hz; the note and its octave are also given. Next comes a printout of the first 22 steps of the PTOF program. Note the compact nature of the RPN code. Each line's interpretation follows: 01—ALPHA Label; 02 and 03—store loop control number in register 00; 04 and 05—store ALPHA string in register 01; 06—display format with no digits following the decimal; 07 through 09—these steps display the PROMPT shown above; 10—the operator's note is stored in the X register; 11—clear flag 22, the digit entry flag; 12 through 14—these steps display the second PROMPT shown in the running program; 15 through 17—if flag 22 is clear, store 0 in register Z. Otherwise, store the octave number there; 18 through 22—some of the alphanumeric manipulations available to the HP-41C user. A complete listing of this program is available from Hewlett-Packard's Users' Library. Write to Hewlett-Packard, Corvallis Division, 1000 Northeast Circle Blvd., Corvallis, OR 97330 for information on how to join the Library.

```
  XEQ  "PTOF"
NOTE?
BF
           RUN
OCTAVE?R/S=0
   -1      RUN
233 HZ, BF/-
1
      PRP  ""

 01♦LBL  "PTO
            F"
 02 .005
 03 STO 00
 04 "CDEFGA"
 05 ASTO 01
 06 FIX 0
 07 "NOTE?"
 08 AON
 09 PROMPT
 10 ASTO X
 11 CF 22
 12 "OCTAVE?
       R/S=0"
 13 AOFF
 14 PROMPT
 15 FC?C 22
 16 0
 17 STO Z
 18 XEQ 05
 19 ARCL Y
 20 ASTO Y
 21 ASHF
 22 ASTO T
```

Listing 3: A printout of the HP-41C's CATALOG 1 function, which lists all user programs in RAM, including the number of bytes required. Total room used here is 1148 bytes. Approximately 1064 bytes are free in the HP-41CV for more user programs, an astounding amount of storage ability for an HHC.

```
            CAT 1
LBL'HEX
END        268 BYTES
LBL'PTOF
END        203 BYTES
LBL'dBV
LBL'VOLTS
LBL'dBM
LBL'WATTS
END        292 BYTES
LBL'Z
END        62 BYTES
LBL'FREQ
END        19 BYTES
LBL'PAR
LBL'RPAR
END        37 BYTES
LBL'HANG
END        262 BYTES
.END.      33 BYTES
```

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nectors. The cables are simple stranded wire; gauge is of little importance. Cable lengths can be up to 10 meters between devices when using simple stranded wire. Distances of up to 100 meters are possible with twisted, shielded, pair wire. Each HPIL peripheral (e.g., printer or data cassette) is equipped with two corresponding mating connectors. Extension cables are available from Hewlett-Packard.

Plug the two loose cables into the side of the peripheral and you're ready to go. If there is more than one peripheral, connect the devices in a sort of daisy chain. In this loop, information passes from a sending device

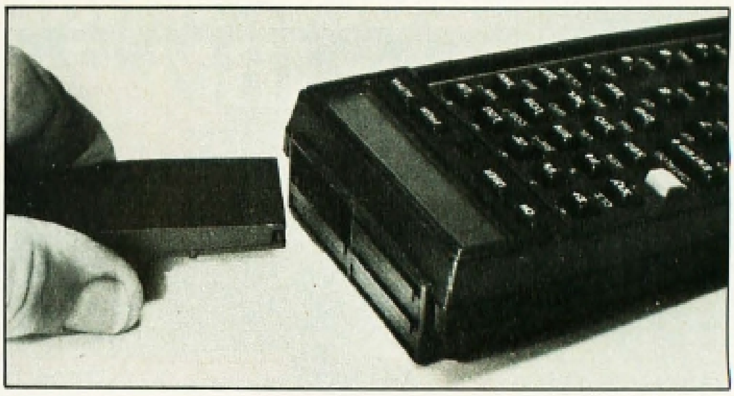

Photo 1: *The HPIL Module.*

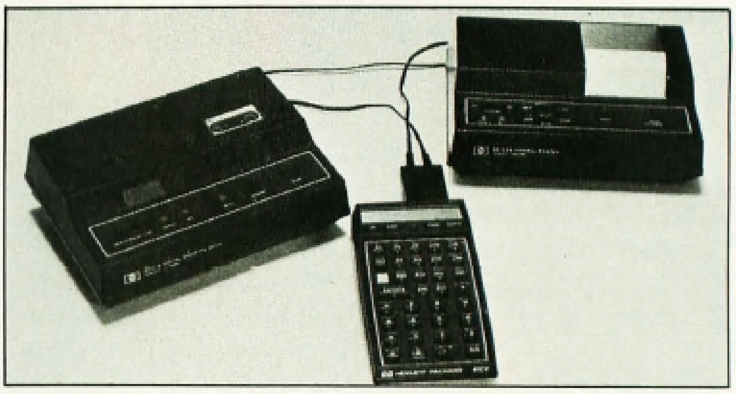

Photo 2: *HP-41C connected to an HPIL Module, Digital Cassette Drive, and Thermal Printer/Plotter in the loop.*

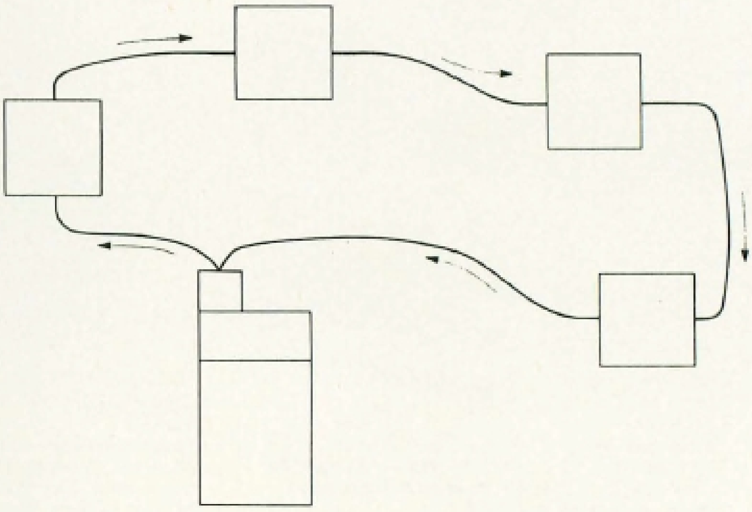

Figure 1: *The HPIL is a continuous loop, with data and instructions traveling from an originating device back to that device for a complete, bit-for-bit error check.*

through all the other devices. When data return to the source, they are completely checked for errors (see photos 1 and 2 as well as figure 1). Since each succeeding battery-operable device uses its own power to retransmit the data it receives, total power in the loop is shared equally, minimizing battery drain. All communication between devices is supervised by the HPIL Module, which is now available for $125.

HPIL Specifications: The New Firmware

As mentioned earlier, plugging a ROM into the HP-41C gives it a new personality. The HPIL Module is no exception. Within it are the routines essential for turning this portable, programmable calculator into a versatile "outside world" controller. Three types of HPIL routines are supported: printer-type operations (also suitable for video display and for controlling external devices); mass storage operations (for digital cassette or disk drive); and interface control operations (largely used for controlling external devices).

The HP-41C as controller can address each device in the loop by a unique number. The HPIL Module is capable of addressing up to 30 devices in the loop, certainly a quantity large enough to satisfy most users. If that's not enough, the addition of a module called the Extended I/O (Input/Output) ROM will allow the HP-41C to extend its address capability to a total of 961 devices on the loop. If still more devices are needed, loops can be connected through an HPIL Converter. (Each loop, however, must have its own controller.) The Extended I/O ROM has additional capabilities which I'll discuss later.

The calculator/controller designates which peripheral is to be a sending device (called a *talker*) because there can be only one talker at a time. The other devices on the loop become *listeners*. When so instructed, listeners can also act upon data passing through. For example, a printer can print information, a video display can display it, etc.

Hewlett-Packard does not intend to publish the actual voltage levels or the digital nature of the commands used within the two-wire HPIL loop. It has revealed that the HPIL communicates with the outside world through the HPIL Converter, a general-purpose interface board designed to be attached to the user's GPIO (general-purpose input/output device) equipment. For example, an original equipment manufacturer (OEM) may wish to install an HPIL Converter within its electronic voltmeter, enabling the voltmeter to be programmed by an HP-41C or other computer. Hewlett-Packard intends to aid other manufacturers by providing all the details necessary for them to successfully communicate with the HPIL Converter. An overview of converter hardware connections will be presented in a later section.

An Asynchronous Communication Loop

Quite a few more essential details are known about the loop's *protocol*. The HPIL is an asynchronous communication loop whose speed self-adjusts to that of the slowest *active* device in the loop. For example, if a slow printer is connected within the loop but is not to be used, the controller can instruct the printer to ignore data/instructions and pass them on to the next loop device. That way the loop can operate at its fastest possible speed. The Extended I/O ROM will even allow a means for the Digital Cassette Drive to pass data to the printer through an essentially inert HP-41C. In this mode, the HP-41C will become a relay device rather than a controller and will not retard loop operation.

HPIL Speed

Just how fast is the HPIL loop? Depending on circumstances, it can approach speeds of 40,000 bps (bits per second). While this is many times faster than most RS-232C serial links, the HPIL can be slower than the parallel-based IEEE-STD-488 bus. (Originally known as GPIB or HPIB for Hewlett-Packard Interface Bus, the present IEEE-STD-488 was developed by Hewlett-Packard.) The HPIL is intended to be a low-cost, non-competitive alternative to IEEE-STD-488. The HPIL *is* competition, however, for the more antiquated RS-232C. Just the fact that the HPIL uses only two wires gives it a definite advantage; then there is the availability of an HHC as a controller.

Let's look at the speed of this asynchronous loop in more detail. Since instructions as well as data are sent around the loop, the instruction cycle of the controller may become a significant factor. In almost all cases, the loop controller will be the HP-41C portable calculator. While microcode (machine language) runs through the HP-41C at a speed of about 350 kHz, the practicalities of the Macro Instruction Interpreter effectively make an instruction cycle much slower. An instruction such as ENTER↑, originally keyed into program memory by the operator, takes about 40 ms to execute. This includes the overhead of the Instruction Interpreter and the HP-41C Operating System. Therefore, practical data throughput speed will probably average about 150 bytes per second (1200 bps). The 40,000-bps HPIL maximum could only be managed by, for example, an HP-80 series computer running a machine-language controller program or by controllers Hewlett-Packard is now developing.

Using the Loop

Operation of the loop can be completely transparent to the user. When a printer is in the loop, the operator (or a running program) simply executes a PRINT function; the HPIL searches for the first available printer to perform the function using a unique feature called an *accessory poll*. Optionally, the operator (or a program) may specify a particular printer by means of the SELECT function. In this case, the operator becomes only a little more involved with HPIL operation.

Manufacturing plants may wish to have the HPIL control a set of relays and read a number of indicators. The HP-41C is ideally suited to that task. Its alphanumeric capabilities and versatile keyboard allow programs to be written so that they can talk to the plant operators in plain English while performing complex underlying operations.

Efficient firmware in the HPIL Module is available, allowing a user to perform READ/WRITE functions onto a mass storage device (such as the Hewlett-Packard Digital Cassette Drive) or PRINT functions. Firmware supports either the Hewlett-Packard printer or any ASCII-compatible standard printer having a parallel port. Using less efficient instruction methods, the present firmware also allows the HP-41C to query and change the status of relays, monitors, voltmeters, or hundreds of other devices.

More Efficient I/O Operation

The Extended Input/Output ROM plugs into the back of the calculator and will add the following functions to the firmware:

- Extended addressing of up to 961 devices on the loop
- User access to all additional functions involved with

Listing 4: *The DIRECTORY that leads every HP digital cassette. Owners of the Card Reader will be interested to know that file ALL is a WRITEALL file containing the complete status of an HP-41CV. This file loads in about 25 seconds as opposed to the several minutes and inconvenience of using over 10 magnetic cards. More than 50 files of this size can be stored on one cassette!*

```
                  DIR
NAME    TYPE    REGS
HEX     PR        39
STATUS  KE         1
TEST    ST        10
ALL     WA       336
PTO     PR        29
dBY     PR        42
Z       PR         9
```

control and query of external devices attached to the loop

• A routine to enable bar-code generation on the new HP82162A Thermal Printer/Plotter

• A routine to allow one or more cassette copies to be generated; especially valuable when distributing software or data for OEM use

• An external device will be able to "call" the controller for service requests

The HP82183 Extended I/O ROM will be available by the summer of 1982, with price to be announced.

Extended Functions/Solid-State Mass Memory

The HP82180A Extended Functions/Memory Module adds firmware as well as additional read/write memory to the HP-41C. While this new product is not directly involved with HPIL operations, it is being introduced now in an effort to make the HP-41C a more "friendly," versatile controller and, of course, an even more powerful HHC. HP-41C owners not interested in controlling external devices can still make use of the Extended Functions/Memory Module. First, this device adds 47 new functions not included in the HP-41C mainframe. Second, the HP82180A and two companion Extended Memory Modules can increase the solid-state memory space of the calculator by 4.2K bytes to a whopping, handheld total of 6.2K bytes.

Many users will look forward to a programmable ASSIGN function, which will enable special-purpose keys to be automatically assigned and later cancelled within specific programs. Previously, key assignments had to be executed manually. Note that the *software-intensive* design of the original HP-41C is what makes these post-production enhancements possible.

Another extended function allows alphanumeric manipulations previously manageable but relatively cumbersome in the standard HP-41C. For example, the leftmost character of an alphabetic string can be identified by a program and then acted upon. The 104-step program PTOF (partially described in listing 2) could be reduced to approximately 80 steps and would run faster with the new extended functions.

Additional memory of 889 bytes is contained in the HP82180A; its companion, the HP82181A Extended Memory Module adds 1666 bytes. Two HP82181A units can be used at any one time. With all three modules plugged in, 4221 bytes of extended memory are available to the user. The additional 4.2K-byte memory is called *extended* memory to distinguish it from the *resident* memory of the HP-41C. Extended memory is not online in the sense that programs can be executed directly or that data can be used directly. Instead, the new read/write memory is organized in a *file and register format*, just as on a disk drive and with equivalent access speed.

For example, two completely different specialized calculators could be kept in solid-state storage and downloaded into the main RAM on demand. ASCII data of up to 4221 characters could be collected and stored in the field to be acted later on by the HHC, by a computer, or transferred to the new Digital Cassette Drive. It will not be necessary to "wipe" information in main RAM in order to move data from the extended memory to the Digital Cassette Drive. Data within the extended memory can also be sorted, alphabetized, or otherwise organized at disk-access speeds. The HP82180A Extended Functions/Memory Module is now available for $75, as is the HP82181A Extended Memory Module.

Industry Reaction to the HPIL

The HPIL is certainly a versatile system, but what's the catch? For now, there *is* one little catch: other manufacturers may design peripherals to attach to the HPIL, but the only loop controller presently available is a Hewlett-Packard product. Therefore, a turnkey system would contain at least two Hewlett-Packard products—the HPIL Converter and an HPIL controller. The company says that the converter hardware will support controller operation. Unfortunately, the software to run a controller is very complex, causing concern over possible improper HPIL operation. Nevertheless, manufacturers who wish to develop a controller for the HPIL may contact Hewlett-Packard for details. Despite the Hewlett-Packard monopoly on the controller, the HPIL will probably become popular with other manufacturers simply because the versatility of Hewlett-Packard's most powerful calculator makes it the ultimate controller.

HPIL Peripherals: The Digital Cassette Drive

To me, the most intriguing new peripheral is the Digital Cassette Drive. Using digitally certified magnetic tape, it is truly a *mass* storage device (see photo 2). Up to 131,072 bytes of online mass storage will fit into a small cassette similar in size to an audio microcassette. The drive itself is compact, and its flip-top cover contains a convenient storage space for two cassettes. The magnetic storage is 50 times the size of the HP-41CV RAM and, according to Hewlett-Packard, contains enough mass memory to accommodate all the programs from the 26 HP-41 Solutions Books onto one tape. If this is not enough online capacity, HPIL firmware even allows "chaining" of multiple drives. The user or a running pro-

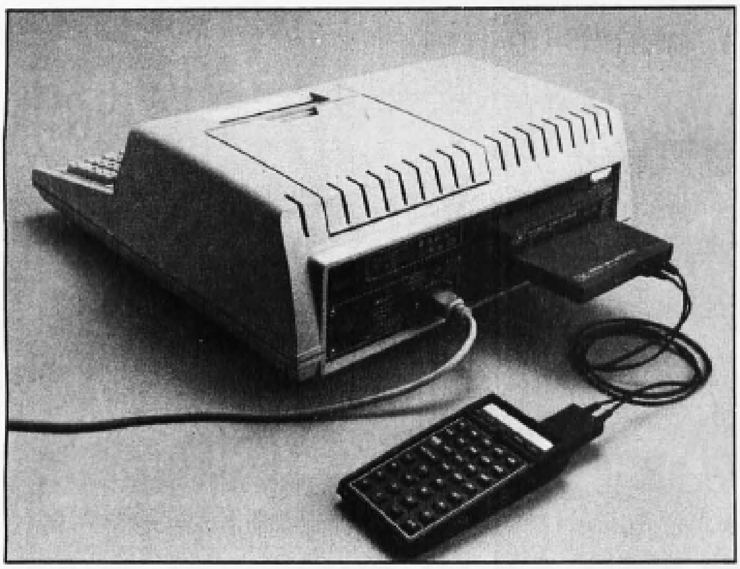

Photo 3: *With the HP-41, HP82160A, HPIL Interface Module, HP-85, and HP82938A HPIL Interface Card, portable data collection, direct data transfer, and sophisticated data analysis are made easy.*

gram simply calls a file by its name. The HPIL firmware searches the directory at the head of each cassette until it finds the selected file, then loads the file from that drive into RAM.

The cassette drive is of digital quality. It records data with parity, and a VERIFY function is available to check for errors. Being HPIL compatible, it can be addressed by controllers yet to be developed for the loop. Powered by rechargeable batteries, the drive has a standby power mode feature, especially valuable where operation on batteries and without human intervention is expected for long periods. The controller *automatically* calls a POWER UP function when it wishes to access the cassette drive. As a result, this unit is truly field operable.

Using a two-track format, the cassette drive is bidirectional (one track per direction) with two speeds: 23 centimeters (9 inches) per second read/write speed and 76 centimeters (30 inches) per second search/rewind speed. For those concerned about potential head wear at these speeds, the company asserts that the tape-to-head pressure is so light that head wear is insignificant. Data density is 335 bits per centimeter. Format is 256 bytes per record, with 512 records available per cassette.

When a file is called, the machine first reads the directory at the head of the cassette for the location of the named file (see listing 4 for an example of a tape directory). Then the cassette rapidly (76 cm/s) winds to the file and reads it back to the HPIL. Before writing a file, the machine looks through the directory to see if the name already exists. If so, it will rewrite (record over) that file. If not, and if space is available on the medium, it will add the new file name to the directory, speedily jump to the free spot on the tape, then record the new file, all under HPIL control.

Seven different types of files may be recorded: Program, Data, Key Assignments, Status (condition of the HHC—useful for reestablishing conditions after a running program has been interrupted), Writeall (entire contents of the calculator), ASCII, and Unknown.

To check the effective speed of the cassette drive, I recorded and then read back a *Writeall file* (2352 bytes). I timed the machine from the moment I pressed the last key of the READALL command to the time the read was completed. It took 27.5 seconds; therefore, effective average speed of data transfer using cassette is 85.5 bytes per second (684 bps). The read/write speed on the medium is a respectable 963 bytes per second, but, as you can see, tape-cuing time must lower the real speed considerably. The same amount of information could be loaded from a typical disk drive in a couple of seconds.

New Thermal Printer

Probably the most important feature of the new thermal printer is its HPIL capability, which allows it to be addressed by future controllers and computers. The HP82162A Printer/Plotter includes all the features of the earlier HP82143 as well as the ability to print bar code. Since it too runs on rechargeable batteries, a standby power mode is included.

For those who are unfamiliar with the earlier printer, its features include: ASCII standard upper and lowercase characters and special characters, double-wide printing option, a 24-character line, user-definable characters, and plotting capabilities. HP-41C users should immediately see the potential of the HPIL interface plus printer plotting—an input signal can now be plotted in real time.

More HPIL Peripherals

The HP3468A Digital Multimeter (DMM) is programmable through the HPIL. Its 12-character alphanumeric display can output messages generated by the controller or by the DMM. Resolution is adjustable from 3 to 5 digits, with increased resolution resulting in a proportional trade-off in speed.

The HP82938A HPIL Interface Card shown in photo 3 plugs into the Hewlett-Packard Series 80 personal computer. The computer will then be able to take control of the loop. It can also be programmed to store and analyze data collected on the calculator. ROMs for the Series 80 machines are compatible with the HPIL Interface Card, allowing the computer to use the printer, cassette drive, and all future HPIL peripherals.

The HP82182A Time Module plugs directly into the HP-41C. This will allow the unit to be turned off and then "awakened" automatically by the timer's programmable ALARM function. The program will start running the line at which the HP-41C was positioned when it was turned off (or when it turned itself off). Since OFF is a programmable function, the process can be repeated indefinitely. The timer becomes especially useful in a controller situation, allowing measurements to be taken at regular intervals, devices to be turned off, pressures regulated, etc. This module can also display time and date and provide calendar data over a 2738-year span.

The HPIL Converter

The key to the HPIL's success will be the availability of

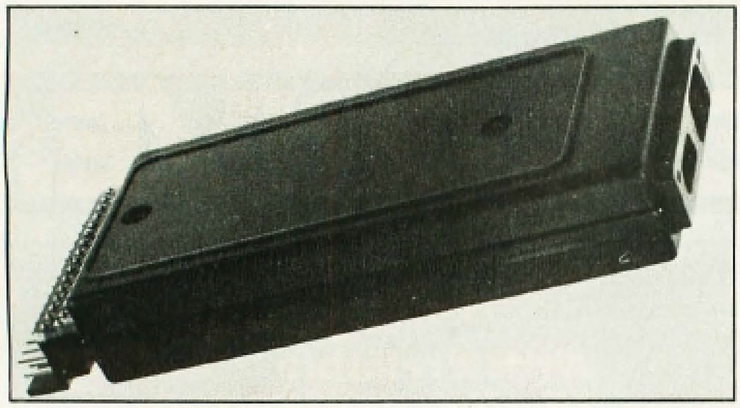

Photo 4: *The HPIL Converter (4.5 by 11 by 2 cm) connects the HPIL loop with the outside world.*

the HPIL Converter. This component (see photo 4) is designed to interface the HPIL with the outside world. OEMs may wish to build HPIL capability into components such as measurement instruments, enabling programmable control by an inexpensive HHC rather than a much more costly computer.

BYTE readers who have connected hardware to computer input/output ports are probably familiar with a VIA (versatile interface adapter) or a PIA (peripheral interface adapter). Applying a similar philosophy, the HPIL Converter is a much smarter device. The converter contains the necessary firmware to recognize HPIL instructions and to convert specific instructions and data from the serial HPIL format to a dual 8-bit parallel format. As a matter of fact, one of the sample schematics presented in the converter manual is an interface with a Centronics-style parallel printer connector.

Hewlett-Packard supplies a 34-pin printed-circuit-type mating connector; a standard ribbon connector will also work. Power for the HPIL Converter (+5 V DC at 90 mA) is derived from the host device. All input/output lines are TTL-compatible and include two bidirectional 8-bit ports, three input handshake lines, three output handshake lines, and several special-purpose lines. The latter are used for triggering external devices and for communicating special conditions such as power down, power up, or service request. Complete hookup details for programming negative or positive logic strobes, full or half duplex operation, and more are furnished in the HPIL Converter documentation.

Some Revisionist Thoughts

The addition of all this hardware to the Hewlett-Packard arsenal poses a couple of logistical problems. The first problem concerns battery charging; there are too many plugs and not enough sockets. The HP-41C, printer, and cassette drive each come with identical-style power connectors. A power transformer and a charging cable are also furnished with each unit. It is certainly inconvenient to have to find wall sockets for all these devices. I hope that Hewlett-Packard relieves the conges-

A Future Day in the Life of an HP-41C

It's morning (February 1, 1983), and I find no cash in my pockets. No, the HP-41C cannot mint money, but it can call the bank for me and engage in a friendly conversation with the bank's computer. I plug the Modem Management Pack into a blank slot and connect the HP-41C to an HPIL converter which in turn has been hooked up to a telephone coupler. I quickly learn that the check from Detroit finally cleared, and my checking account is good for $1000.

Later, I arrive at the recording studio and discover a faulty VU meter (things haven't changed much). I am now carrying a powerful tool consisting of my trusty HP-41C attached to an HPIL Converter, an A/D (analog-to-digital) converter, and a long cable terminating in alligator clips. These components make up not just a programmable multimeter, but a complete measurement and analysis system customized by the user—me!

The HHC tells me that there is 2.0 V across the console's output terminals, which represents 4.2 dBs above the reference of 1.23 V. I suspect an intermittent connection, so I've programmed the HP-41C to beep whenever a change in level occurs (a high-frequency beep if the level goes up, low-frequency if it goes down) and to display the new voltage and dB level. When I wiggle a loose resistor on the circuit board, the HP-41C cheerfully beeps to signal the cause of the problem. Even in 1983, cold solder joints and bad connections cause the majority of service problems.

My next job is rather distantly located, but this time the HP-41C is not available to play Hangman. It has a much more important job to do—it's helping to fly my Beechcraft. You see, back in 1981, the Hewlett-Packard company produced a custom ROM for the Beech Aircraft Corporation, turning the HP-41C into a revolutionary flight-planning system capable of saving thousands of gallons of fuel a year. Well, today (1984?) this system has been updated so that the plane is equipped with an HPIL Converter. Since instrument data is now transmitted directly to the HP-41C, the pilot does not need to key in information about fuel flow, speed of descent, wind velocity, or air speed.

Of course, as soon as I get the money, the next step will be to purchase the HP-41C Auto Pilot. By 1985, I will be able to plan my flight at home on the portable HP-41C, carry it with me to the airport, and plug it into the control panel of my airplane. Thus, it will help me in the air and continue to serve me on the ground.

The preceding "science fiction" story is based entirely on components that are available today and on technology that is completely within reach. We have only begun to dream.

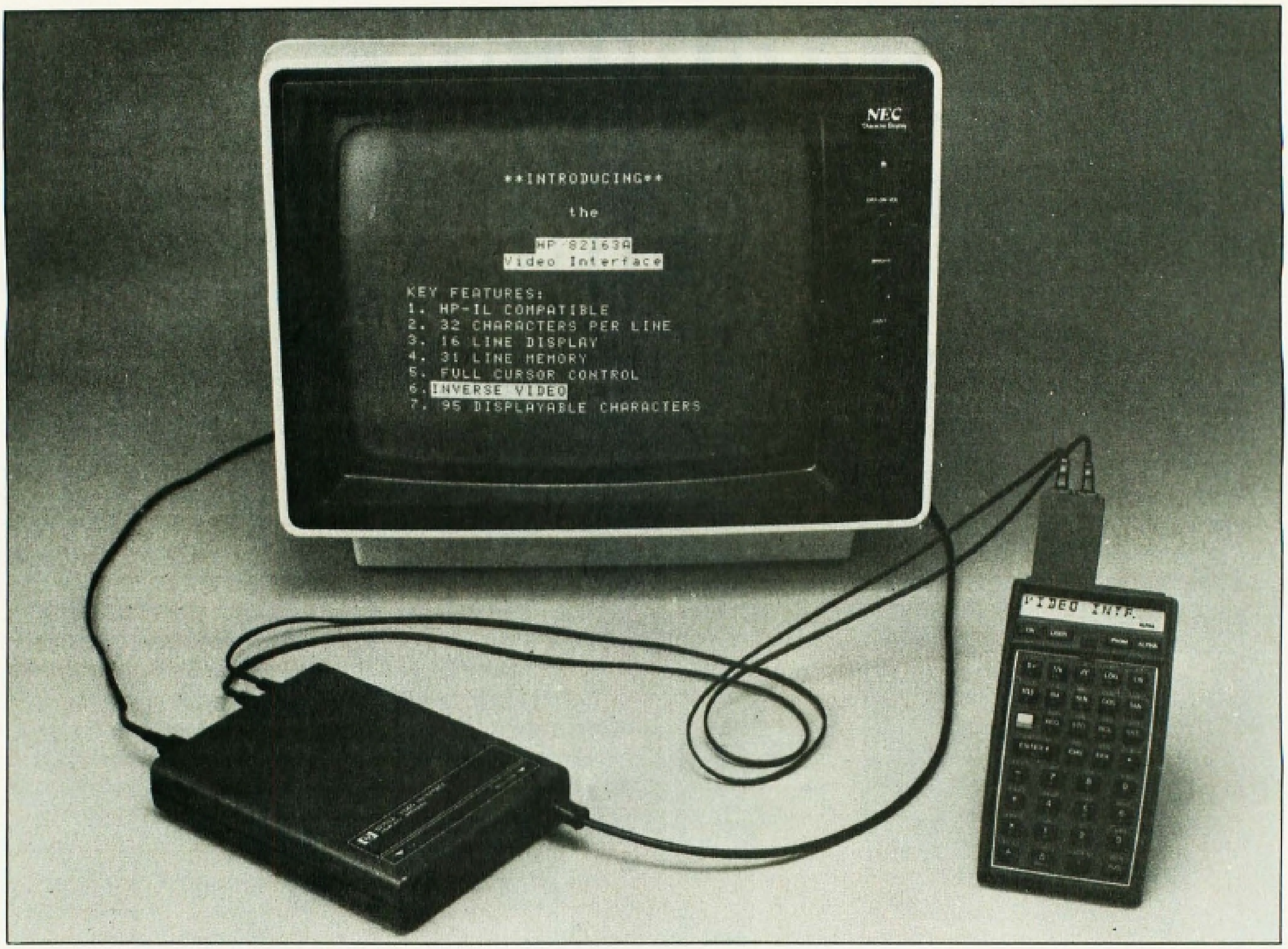

Photo 5: *Hewlett-Packard's HP82163A Video Interface connects a monitor or TV to HP's interface loop. This permits handheld computers like the HP-41C—previously limited by a single-line display—to display information in a 16-line by 32-character video format. Aided by the new interface (available by the end of 1982), HP-41C owners can review up to 16 program steps at a time.*

tion by introducing a charger capable of powering several peripherals at once.

The second logistical problem is more serious. Hewlett-Packard has supplied a "horn of plenty" in modules, but there are only four sockets to receive them. A user may very well need to operate several of these modules simultaneously. Hopefully, the company will soon supply a "piggyback module adapter" of some sort to relieve the problem. Outside of the above, very few complaints can be made about Hewlett-Packard's well-supported products.

The Future

With the introduction of the HPIL Loop, Hewlett-Packard has made a commitment to issue a series of new HPIL controllers, peripherals, and instruments. Expect to see in the near future a video/TV monitor interface (shown in photo 5), an 80-character/line impact printer, an HPIL/RS-232C converter, and a self-powered version of the GPIO board designed for the home hobbyist. No official corporate announcement has been made at this writing, but Hewlett-Packard probably will introduce these items before the end of the year.

I'm sure someone will ask about word processing with the HP-41C and the HPIL. It's conceivable but not without an external keyboard since the HP-41C is only good for "hunt and peck" typing. Its alphanumeric capabilities and portability will lend themselves to many other unique jobs in the very near future.

Conclusions

As usual, Hewlett-Packard's documentation is excellent. Prototypes of the new products must have been in use within the Corvallis, Oregon, plant for a considerable length of time because the style of the instruction manuals reflects much experience with the products.

With any new and complicated product, there are bound to be bugs. The ones I have found so far have been minor. My experience is that Hewlett-Packard's Corvallis Division will respond to consumer complaints quickly and efficiently.

The potentials of the HPIL loop are literally awe-inspiring. As such, it is difficult for me to make an overall evaluation other than that the future looks bright. I suggest you read on to page 94 and delight in what's just over the HPIL horizon.■