Store and Recall on HP Calculators – The First Decade

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Introduction

Most calculators, even the lowest cost minimal featured ones, have the ability to store and recall at least one number. The first HP calculator, the scientific HP-35A**(1)**, introduced in January 1972 had one storage register. Two keys, STO and RCL, were dedicated to this feature. See Fig. 1. In nearly every case the memory storage register has the same capacity as the display, and it is dedicated to the user's use.

Fig. 1 – HP-35A.

As memory technology advanced the number of data registers increased with later models offering hundreds of "data registers" available to the user. In some early HP models the use of data storage registers is shared by the calculator's functions. The user must be aware of the ones that may have unexpected data in them, and that they may even be cleared by the sharing, usually statistical, function(s).

This article will review the storing-and-recalling-of-data feature found on HP calculators. HP has been very creative in the way that data storage memory has been used.

Register sharing came first

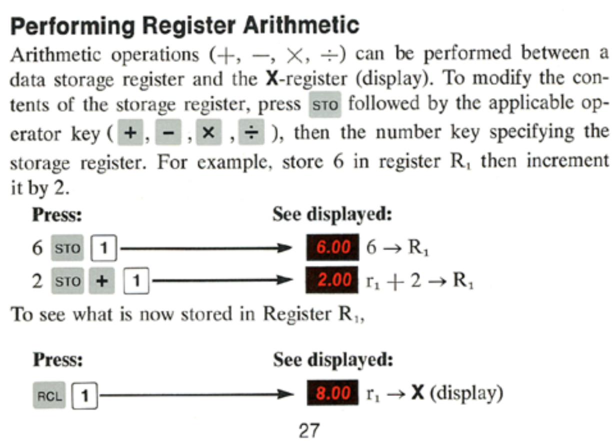
The second HP calculator, the financial HP-80A**(2)**, followed the HP-35A 13 months later. The scientific machine required the user to apply the formulas applicable to the broad fields of science and technology. The financial calculator, however, had the many finance formulas needed in the business world built in. This required 2-1/3 times the ROM memory. Memory was very important, but still technologically limited. Several of the HP-80A statistics functions even used some of the stack registers for their use. This made statistical function use a bit "tedious." The HP-80A single data register was called a "constant storage location" similar to the HP-35A. At the time, however, the HP-80A was many times faster and more accurate than any other financial computational method available to the average user.

Unique storage features happened quickly

The third HP calculator, the scientific HP-45A, followed the HP-80A three months later (5/1/73). The number of storage registers increased to nine and the STO/RCL operations increased in their capability.

These three machines are classical RPN calculators. The STO and RCL operations, however, were not RPN in the way that the machine used them. RPN is postscript logic wherein you provide the data followed by the operation. Storing a number, e.g. 7, in Register 1, should have the RPN sequence 7, 1, STO. Instead the sequence is 7, STO, 1.

This is explained by the inventor of HP calculators, Tom Osborne. Tom explained this during an interview of the HP-35A development team during a special event at HP Labs when the IEEE presented a plaque honoring HP on May 14, 2009. See ***HP Solve*** Issue 14, RPN Tip #14**(3)**, near the end of the article. *"I probably would have used postfix on store if we had more than 10 storage cells (0-9), but "STO N" seemed much more easily understood than "N STO". However with more than 10 numeric memory cells then RPN would have won because it saves a keystroke. "STO 11" would have to be "STO 11 Enter" vs. "11 STO"."* The HP-45A was the first to add the feature of register arithmetic. Fig. 2 shows how the HP-45 Owner's Handbook explains register arithmetic.



Performing Register Arithmetic

Arithmetic operations (+, −, ×, ÷) can be performed between a data storage register and the **X**-register (display). To modify the contents of the storage register, press STO followed by the applicable operator key (+ , − , × , ÷), then the number key specifying the storage register. For example, store 6 in register R_1 then increment it by 2.

Press:	See displayed:	
6 STO 1	6.00	$6 \rightarrow R_1$
2 STO + 1	2.00	$r_1 + 2 \rightarrow R_1$

To see what is now stored in Register R_1,

Press:	See displayed:	
RCL 1	8.00	$r_1 \rightarrow$ **X** (display)

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Fig. 2 – The HP-45 Owner's Handbook explains register arithmetic on page 27.

Tom's brilliant engineering set the tone very early for keystroke efficiency, a hallmark of HP calculators.

Register arithmetic makes perfect sense when memory is scarce (expensive). A data register is then able to serve multiple purposes. The most obvious example of multiple date register use is as a summing register. The HP-45A is not programmable, but using register arithmetic in a program could increase program efficiency as well.

The nine storage registers of the HP-45A (R1 – R9) were not completely without restrictions. R5 – R9 were shared by other calculator functions. See Fig. 3 text from the Owner's Handbook, OH, for the details.

Restricted Storage

Registers $R_5 - R_8$

Registers $R_5 - R_8$ are used internally when performing summations using [Σ+] and [ ] [x̄,s]. When summations are not being performed, these registers may be used for general purpose storage. However, since registers $R_5 - R_8$ are not overwritten by new values, they must be cleared of existing values by pressing [ ] [CLEAR] before they are used in summations.

Register R_9

Register R_9 is required internally when performing trigonometric functions and polar/rectangular conversions; any values stored there will be lost. Otherwise, register R_9 may be used for general purpose storage in the same manner as registers $R_1 - R_4$.

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Fig 3 – HP-45A OH Restricted Storage description.

Recall arithmetic applied as well. The HP-45A Owner's Handbook explains. *"Conversely, to alter the X-Register (displayed value) without affecting the contents of the data storage register or the other stack registers, press RCL, the applicable operator, then the number key specifying the storage register."*

The statistical registers may be also be used as summing registers (R7 ∑x & R8 ∑y). Using the ∑ key to store the sums of two numbers at the same time is very keystroke efficient without using register arithmetic.

The next major advancement in HP calculators was to add programming with the introduction of the HP-65A on January 1, 1974. This machine caused an explosion of HP calculator user activity(4). Memory was still relatively expensive and the HP-65A, like the HP-45A, had nine data registers (R1 - R9).

Fig. 4 at the right provides the HP-65A Owner's Handbook details of the usage of the nine data registers - on pages 29 & 30.

The HP-65A was programmable with enough memory for 100 program instructions, and it is possible to key data into program memory. Each digit, sign, decimal point, and EEX required a program instruction. Depending on the number of digits, etc. the 100 program instructions could consist of the data followed by a STO N. This data is then recorded on a magnetic card. To store data in the nine data registers you read the card and press the R/S key. This process is much easier and faster than storing the data as needed. An example would be English-Metric conversion factors for a program. Memory was very limited and the magnetic card off-line storage was a powerful asset for a machine that lost all memory when the power switch was turned off.

Choosing Addressable Registers Registers 29

Except for the case of registers R_8 and R_9, it is immaterial as to which registers you use.

R_8 is the special object of the *Decrement and Skip on Zero* ([g] [DSZ]) operation (*presented in* **Section 4**), which uses it as a descending counter (*index*) in program applications. If this use is contemplated, R_8 should be avoided for other uses. Otherwise, it may be freely used.

R_9 is subject to alteration by the trigonometric functions (*including the rectangular/polar conversions*) and the relational tests (*used in programs*). These functions use R_9 for intermediate calculations (*scratch*). At other times R_9 is available for your use.

The following operations destroy R_9:

[SIN] [COS] [TAN] [R→P] (trigonometric functions and their inverses)

[x≠y] [x≤y] [x=y] [x>y] (relational tests)

Calculating in Addressable Registers

Thus far, all calculations have involved the **X**-register or the **X** and **Y**-registers to produce a result in **X**. In the case of addressable register arithmetic, the result is left in the addressable register and **x** is unchanged.

Subtraction.	To subtract x from r_n, press	STO [−] [n]
Addition.	To add x to r_n, press	STO [+] [n]
Multiplication.	To multiply x and r_n, press	STO [×] [n]
Division.	To divide x into r_n, press	STO [÷] [n]

For example, store 6 in register R_1 and then increment it by 2.

Press	See Displayed	Comment
6 STO [1]	6.00	Stores 6 in R_1.
2 STO [+] [1]	2.00	Adds 2 to r_1.
RCL [1]	8.00	Confirms that r_1 equals 8.

Now, subtract 5 from the contents of R_1.

Press	See Displayed	Comment
5 STO [−] [1]	5.00	
RCL [1]	3.00	Confirms that r_1 has been reduced to 3.

Finally, multiply the remaining contents of R_1 by 2:

Press	See Displayed	Comment
2 STO [×] [1]	2.00	
RCL [1]	6.00	Confirms that r_1 has been increased to 6.

Fig. 4 – HP-65 OM register arithmetic.

Register use is "re-defined"

The next (second) finance machine, the HP-70A(5), introduced 8/1/74, had two data registers called the M and K registers. Fig. 5 shows how the keys were labeled and Fig. 6 shows how they were described.

The M register is the familiar data register. You store by pressing N, STO, M. You recall by efficiently pressing M. The M+ key provides a summing function. The K register is similar except that K has a default value of 12, an obvious monthly number, stored in it when the machine is turned on. The M+ key idea is used on machines such as on the HP-01, HP-10A, HP-10B and HP-21.

Fig. 5 - HP-70A STO/RCL keys.

Storing and Recalling Numbers

Two general purpose memory registers are provided apart from the stack. One memory register (M) is primarily useful when you need to store data for use in subsequent problems or for accumulation. The other memory register (K) will probably be most convenient to use in repetitive calculations where one value remains the same (constant).

Although the store and recall functions work identically for both memory registers, since each has been assigned special purpose features to extend its use, we have described them separately.

Fig. 6 – HP-70A OH description of data registers.

Classical RPN data register addressing method is expanded further

The Classic RPN issue of addressing registers, e.g. R1 – R9 is explained by Tom Osborne in Note 3. Statistical functions need registers, conversion and scientific constants need registers. Users found that entering numeric data from a program was relatively slow so computational variables stored in a data register offered several advantages. These, and many other justifications, provided the need for additional numbers of data registers. The programmable scientific HP-55A calculator was introduced a year after the HP-65A (1/7/75).

The feature that made the HP-55A famous was its crystal controlled timer. HP-45A users discovered that the code for the timer was included in the HP-45A[(6)], but without a crystal or HP documented means to access the code. Many users installed their own quartz crystal to have their own HP-55A timer.

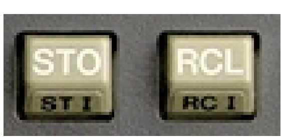
The HP-55A did not have register arithmetic, and program memory was limited to 50 lines (instructions). The number of data registers, however, more than doubled, (from 9 to 20) what was previously available. The registers were addressed as R0 – R9, and R**.**0 – R**.**9). The method of using zero and the decimal point retained the by-then-well-known method of addressing data registers. This provided the "lowest keystroke count" implementation that HP is so well known for.

Fig.7 - HP-55A.

Even more data registers

The next programmable scientific calculator, the HP-67A[(7)], added 6 additional storage registers and a new scheme that changed how they were used. Keystroke efficiency must have been strongly considered as shown in Fig. 9.

The top row of five keys were identified A – E. Associated with these keys were five primary data registers plus a 6th "I" register. See Fig. 8 below. A second 10 registers were called secondary registers, R0 – R9. If you wanted to store N into register A you put N in the X register and pressed STO, A. e.g. N, STO, A. The "I" register required a shift STO. If you wanted to store the number into a secondary register you pressed N, STO, 0. In this way 16 registers (A-E, I, & R0 – R9) could have values stored and recalled by pressing two keys.



F8 – HP67A Keys.

A second set of ten secondary registers, Rs0 – Rs9, are protected and shared with other calculator functions. A special function, P≷S, exchanged the contents of the two sets of secondary registers. The STO and RCL keys would operate as they did normally. Fig. 9 below shows how all the data registers are designated.

The "I" register is a special indirect addressing register that is also shared between the user and the machine. A related STO & RCL calculator function is a register review feature introduced in the HP-67/97 calculators.

Another feature related to the SRO/RCL functions is the clear register function. This function clears all of the primary data registers. To clear the secondary registers the P⇄S key is pressed and the clear register function executed again.

Another advantage the HP-67A offered over the HP-65A is that the data registers were recorded onto a magnetic card.

From the above description it should be clear that keeping track of which register values are in the R0 – R9 primary vs. secondary registers is up to the user.

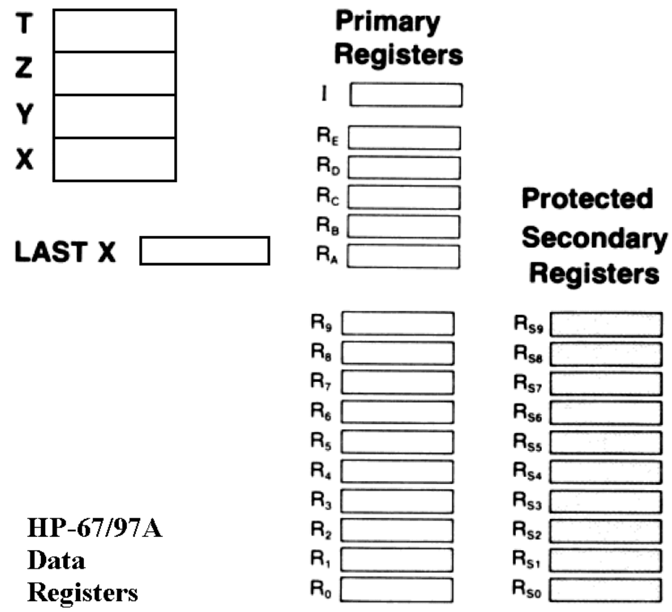


Fig. 9 – Data register designations of the HP-67/97A.

One register six keys

The STO and RCL features of the seven machines described above comprise the calculators that HP made in the first five years of calculator manufacturing. These are the machines of the historical Classic series.

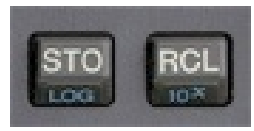


Fig. 10 - Top: HP-21 STO and RCL keys.

Right: Shifted Memory function keys provide register arithmetic.

Following the Classic series is the Woodstock series of HP calculators. These were smaller and lighter and they picked up where the classic series left off. There are four scientific models and two business models. The Woodstock series is a transition series in that Continuous Memory first appeared towards the end of the series. The low priced HP-21 was the entry Scientific model having an M data register. The next scientific model was the HP-25 and it was programmable with 49 steps. It has eight data registers, R0 – R7, storage register arithmetic, and register sharing with the statistical registers (R3 – R7). The HP-25A was famous because it was cost effective, and the HP user community considered it a great challenge to squeeze many advanced level programs into its limited memory. Keying 49 steps for a program wasn't a tremendous time challenge and was reasonable because turning the calculator off cleared all memory.

Along with the HP-25A came the third finance calculator, the HP-22, with its ten data registers R0 – R9. Register arithmetic was also provided, and R5 – R9 were shared with the statistical functions.

The next calculator was a more capable (and more expensive) finance calculator - the HP-27. This was a special calculator because of its unusual mix of business and scientific functions. The HP-27 has 10 data registers, R0 – R9, with full register arithmetic. A display indicator "OF" indicates when register values exceed 9.9999999×10^{99}. A clear storage register function clears all registers. R4 – R9 are shared with the finance functions (R7 – R9), and the statistical functions ∑+ (R4 – R9). Even some of the stack registers are used/altered.

The penultimate member of the Woodstock series (1975 – 1977) was the HP-25C. The difference was the suffix letter "C" for Continuous Memory. This meant that data registers (and program memory) retained their contents when the calculator was turned off.

Continuous memory and even more data registers

The last machine of the Woodstock series is the HP-29C[8]. The HP-29C/19C has 98 program steps and 30 data registers designated as shown in Fig. 11.

Sixteen of the 30 are primary storage register addressed as R0 – R.5. The remaining 14 registers are indirect storage registers addressed by placing the register number (R0 – R29) in R0 and executing the STO I function. These 30 registers may have their values indirectly stored, recalled, and operated on with storage-register arithmetic. A number outside the range of 0 – 29 stored in R0 will error if the indirect function is performed.

The decimal part of the R0 register number is ignored and it may be negative for rapid reverse branching in a program. The HP29C also has a register clear function.

Automatic Memory Stack	Primary Storage Registers	Indirect Storage Registers
T	R_0	$R_{(16)}$
Z	R_1	$R_{(17)}$
Y	R_2	$R_{(18)}$
X	R_3	$R_{(19)}$
LAST X	R_4	$R_{(20)}$
	R_5	$R_{(21)}$
	R_6	$R_{(22)}$
	R_7	$R_{(23)}$
	R_8	$R_{(24)}$
	R_9	$R_{(25)}$
	$R_{.0}$	$R_{(26)}$
	$R_{.1}$	$R_{(27)}$
	$R_{.2}$	$R_{(28)}$
	$R_{.3}$	$R_{(29)}$
	$R_{.4}$	
	$R_{.5}$	

Fig. 11 – HP-29C Data Registers.

"Different" storage registers

The (first) HP-10[9], 7/1/77, is a one of a kind printing calculator obviously intended as an office calculator and is neither a business nor scientific calculator. It has two storage registers, The Accumulator and Memory. Per the Owner's Handbook: "*Basically, the accumulator is a memory that holds numbers while you perform other calculations*." The Accumulator is associated with the double high blue + /= key (see Fig. 12) and accumulates values as numbers are added or subtracted. This key is typical of adding type machines.

The HP-10A Memory is described as a "holding" bin or storage place for numbers. The complete keyboard is shown at the right in Fig. 12. Note the three "M" keys in the top row. Note that the gold shift key only has three functions associated with it.

Fig. 12 – Complete HP-10A Keyboard.

Less data memory for a lower cost

The last two years of the first decade (70's) of HP calculators brought us the Spice/Spike series of calculators. These machines are also called the "E" series because the first five models had an "E: suffix. Two of the three remaining models were unchanged and were the Continuous Memory versions with the same model numbers and a "C" suffix. The models were: Scientific; HP-31E. HP-32E, HP-33E, HP-33C, HP-34C. Business; HP-37E, HP-38E, HP-38C.

The "E" Suffix meaning was hinted at in the HP newsletter, HP Key Notes, as "Extensive low-end product line" Many users believe the "E" stands for Economy. Fig. 14 on the next page illustrates that the HP-31E was directed at students. $60 in 1978 is equal to $213.73 today[10].

The HP-31E Owner's Handbook was in two parts. The basic 17 page booklet and a 56 page "Solving Problems with Your Hewlett-Packard Calculator[11]." Data register usage is described in the later booklet which was also used with several "E" series machines. The HP-31E had four unshared data registers, R0 – R3. Fig. 13 shows the related data register keys. Note the CLEAR REG function.

The HP-32E was the next "E" machine and it was a step up from the HP-31E. The 32 was also nonprogrammable, but added more conversions, statistics and 15 data registers, R0 – R8 and R.0 – R.5. These registers also provided storage arithmetinc.

R**.**0 – R**.**5 and the Y-register were shared by the statistical registers.

The last "E" series scientific was the HP-33E. It has eight data registers, R0 – R7 with R2 – R7 shared with the statistical functions. Fig. 15 shows the HP-33E data register designations.

Fig. 13 – HP-31E STO and RCL related keys.

The First finance "E" series machines was the HP-37E. It has seven data registers, R0 – R6.

The previously four mentioned "E" machines were simple and non-programmable. The remaining four machines are more powerful and have more memory.

Fig. 14 - HP's lowest cost 1978 scientific; the HP-31E.

Data memory shared with program memory

The HP-38E business calculator was HP's first programmable business calculator introduced 5/1/78. With up to 99 lines of program memory it also shared statistical registers R1 – R6. The default memory allocation is eight lines of program memory and 20 storage registers. Each additional program line consumes part of a data register starting with R**.**9.

Each data register provide an additional seven lines of program. See Fig 16 and 17 for the HP-38E memory register allocations. When you add the ninth program line memory is automatically taken from the last data register, R**.**9. While this may seem strange based on today's machines it is important to keep in mind that this was the state of the art in mid-1978. As shown in Fig. 15 the display was still power hungry LED's and the batteries were rechargeable NiCad's.

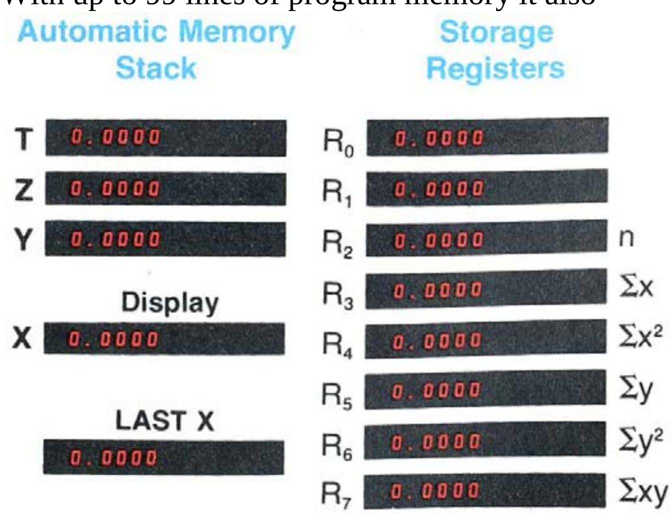


Fig. 15 – HP-33E register designations.

Continuous memory arrives at the end of the "E" series 7/1/79

The HP-33C is identical to the HP-33E except that program and memory do not disappear when the power is turned off. The HP-38C is identical to the HP-38E.

The big news of the "E" series was the scientific HP-34C. This was a new machine and it didn't have an "E' predecessor. Memory was a minimum of 70 program lines and a maximum of 210 program lines when the 20 data registers are similarly used as shown in Fig. 17. The major contribution for the HP-34C

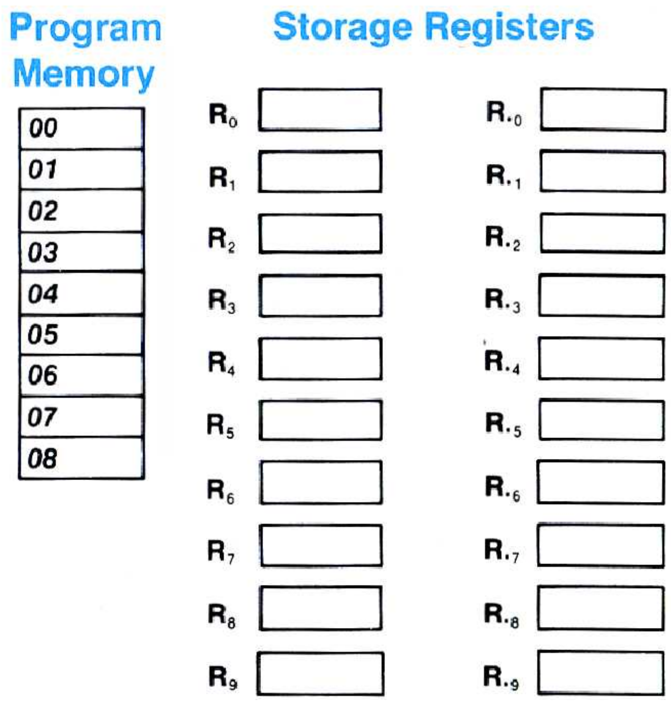


Fig 16 – HP-38E register allocation. 1 reg = 7 prog lines,

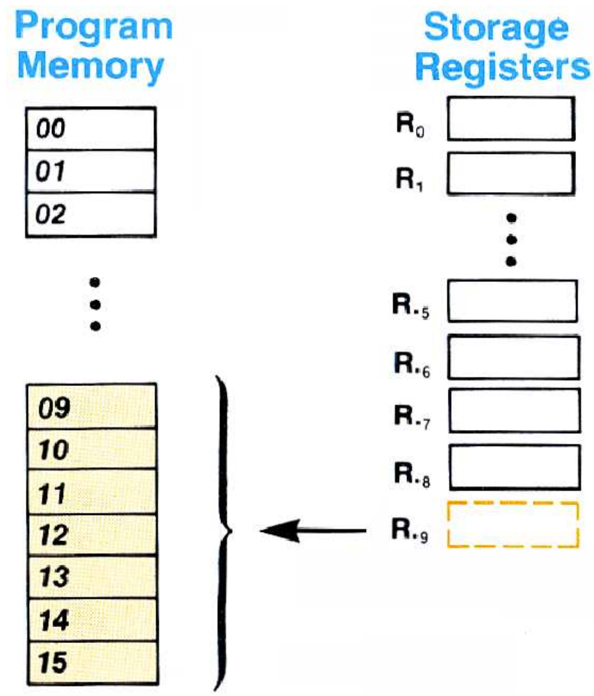


Fig. 17 - Additional prgm. lines consume data reg.

was the new and extremely powerful applications of Solve and Integrate.

Continuous Memory was a technology advancement that once started made it obvious that all HP calculators would soon be made using the CMOS process that needed such a low power that the machine is really never turned "off."

CMOS memory and HP-41 changes everything

1979 was a milestone year for HP calculators because of a new calculator concept represented by the HP-41C/CV/CX. The HP-41[(12)] utilized CMOS memory and it used an alphanumeric LCD display. It had a substantial amount of memory, and it had four I/O ports. The HP-41 is more than a calculator, it is a calculator system.

Prior to the HP-41 calculator models changed frequently, and a product life of about 18 months was normal. The HP 1979 calculator lab manager, Bernie Musch, suggested that because the HP-41 was a system it would have a product life of at least five years. He was happily mistaken when the HP-41 product life was double his expectations.

Because of the unique HP Corporate wide support given to the many accessories of the HP-41 it was used in every technical field from engineering to space[(13)] exploration and by everyone from students to doctors.

The first/basic model, the HP-41C, had 63 storage registers expandable (with memory modules or an HP-41CV) to 319 (R0 – R318) registers. These registers could be used for both program memory and data storage in a manner similar to what has been previously described except that the user specified the number of registers with a size function. Memory "reallocation" was not an automatic process. The memory organization is shown in Fig. 18. The user executes SIZE and then provides a number in response to a prompt similar to the STO function. Each data register uses seven bytes of program

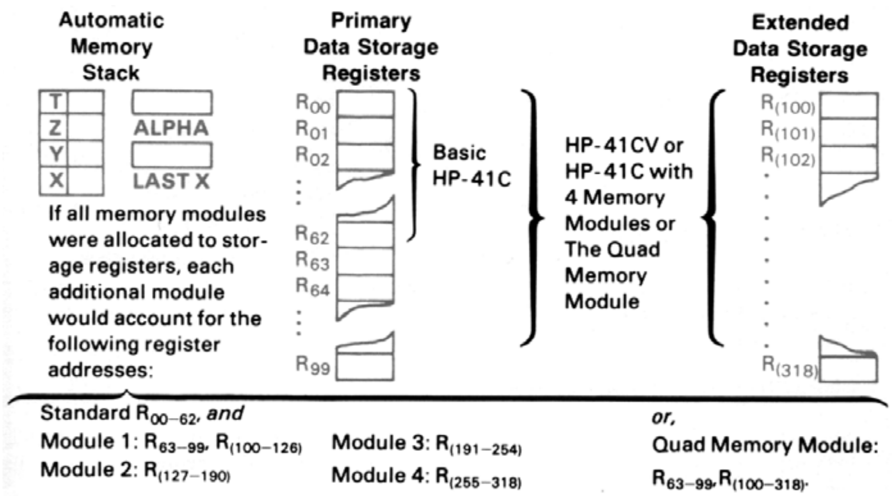


Fig. 18 – HP-41 Memory organization. The user sets the number of data registers with the SIZE function.

memory. Memory management is a bit involved because of the many combinations of models and memory modules for the four expansion I/O ports. The HP-41CX model provided additional modules built-in with maximum memory.

Data registers could be recorded on magnetic cards – the same ones as the HP-65A and HP-67A. Aside from the many 3rd party memory products there were other considerations for memory data registers e.g. the ALPHA register could also be used to store data if necessary. Another example is functions for the storing and recalling numbers into the stack registers. Another example is the use of synthetic programming[14] to access registers not normally available.

The HP-41 was a single line alphanumeric calculator and data storage requirements were impacted because a given register could store either a number or a small number (6) of alphanumeric characters. All registers (stack, LAST X, and Data) could be used for alpha characters.

The basic data registers are the primary storage registers R00 – R99. The STO and RCL operations require two digits. The display prompts for the register number with two underscore characters. The HP-41 has a register clear, CLRG, function. Storage register arithmetic may be applied to the primary data registers, R00 – R99. Storage register arithmetic may be performed on the stack as well. The HP-41 will also provide a register overflow message "OUT OF RANGE." A nice additional feature of the HP-41 is the ability to ignore error messages under the control (flag setting) of the user.

Data registers are used by the HP-41 for statistics functions. The normal six registers, however, are not fixed in that the user may set the starting register with the ∑REG function. The HP-41 keeps track of where these are and a CL∑ function will clear these six registers.

The HP-41 will use any register as an indirect addressing register with an IND function. When the sequence STO IND is executed the display will prompt with STO IND _ _. The user then provides the register number (or alpha designation) of the register to use for the register address. If you have SIZEd your machine to have more than 99 data registers you must address them indirectly i.e. three digit numbers R100 – R318. The alpha and stack registers may also be addressed indirectly. While not relevant to the data registers the HP-41 may take numerical arguments for certain functions indirectly, e.g. TONE, FIX, DSE, GTO including storage arithmetic and flags.

The HP-41 has two flags that may detect data entry, an ALPHA input flag (23) and a numeric input flag (22).

Summary, observations, and conclusions

Most calculators have the feature of providing one or more storage registers for storing numbers for use during a calculation or for future use (sums, constants, etc.). This article is a review of the use of data registers of the calculators HP made during the first decade of their calculators, the '70's.

Business and scientific calculator applications may require a surprising number of data registers and the calculators of this period ranged from one to 319 registers. In most cases these data registers are shared with the user by statistical functions that usually need six registers (and the stack) when they are used.

In addition to function sharing many HP calculators have a feature of performing storage, and in some cases, recall arithmetic in the data registers. In more advanced machines such as the HP-41 register arithmetic is allowed in the stack as well. Because the HP-41 is an alphanumeric machine alpha characters as well as data may be stored in data registers.

Programmable calculators often have a memory tradeoff feature wherein program memory may be used for data storage. In all cases HP has designed their data register usage to be as keystroke efficient as possible.

Store and Recall on HP Calculators – Notes

(1) *The classic model numbers; 35, 45, 65, 55, 67, 80, & 70 are suffixed with "A" to avoid confusion with later models, and to serve as a reminder of their history. The HP-35A designation was used internally by HP and is documented in* http://hhuc.us/2007/Remembering%20The%20HP35A.pdf

(2) *The HP-80A Owner's Handbook is a shirt pocket size similar to the HP-35A, but much thicker. It did not have an Index, but the detailed Contents provide a workable substitute.*

(3) *RPN Tip #14 may be downloaded at:* *http://www.hp.com/large/calculator/august09/the-rpn-stack-future-past-pt-2.pdf* *This is part 2 of an article discussing the Classical RPN stack. Most readers may not realize that the HP-35A predecessor, the HP 9100A, was actually a combination of infix and postfix. The electronics dictated the decision to go forward with Classical RPN in the machines that followed. Tom Osborne further explains.* "No one that I knew at HP Labs was familiar with RPN when I designed the 9100A. The green machine I took to HP was an interesting combination of infix for multiply and divide but post fix for add and subtract. The 9100A stack was high enough to solve most of the normal computations we encountered. With a bit of mental parsing on the input a 2 deep stack can solve any two operand problem, so we were more than covered. A really deep stack is required if one goes formal and leaves all of the operands in their original order and then relocates the postfix operators (as a full blown parser does)." *A full blown parser was implemented by others in much later HP machines.*

(4) *The worldwide HP Calculator user Group known as PPC (new models caused the name change) was founded in June of 1974. The club publications – long before the Internet – provided programs and technical information to greatly increase the usage of HP's calculators. The leadership of PPC continues today with HP calculator user activities such as small group meetings and the HHC Conferences.*

(5) *The HP-70A was an unusual business calculator for several reasons other than the data register usage. The HP-80A replaced the double wide ENTER key with SAVE. The HP-70A brought it back with a bright orange color. The double wide ENTER key was then retained on business calculators going forward. Collectors actively seek this machine because it is very difficult to find.*

(6) *The HP-45A timer could be invoked by pressing RCL and then pressing CHS 7 8 all at the same time. Once in timer mode, CHS toggled it between timings and stopped.*

Store and Recall on HP Calculators – Notes Continued

(7) The HP-67A was part of a "matched" pair of calculators. The other machine was the HP-97A which was a thin desk top machine with thermo printer. Programs (without printer functions) could run on either machine.

(8) The HP-29C was part of a "matched" pair of calculators. The other machine was the HP-19C which was a small desk top machine with thermo printer. The HP-29C was the first machine of the last RPN Stack list logic change as described in Table 1 on page 42 of ***HP Solve*** *issue 27.*

(9) HP has used the "10" model number more than any other number. Examples are: HP-10A, HP 10B, HP 10 BII, HP 10bII, HP 10BII+, HP-10C, HP 10s, and HP 10 Quick Calc. The space in Quick Calc is shown on the machine and was not actually intended as represented in the "named" models that followed. The HP calculator collector would have more than these eight models because of color variations sold with the same model number. For detailed information on the sharing of model numbers see ***HP Solve*** *issue 20 page 25. The "A" suffix is added here to indicate it is the first HP 10.*

http://h20331.www2.hp.com/hpsub/downloads/Newsletters_HP_Calculator_eNL_08_August_2010.pdf

(10) The cost in 2012 is based on the Federal Reserve Bank of Minneapolis consumer price index, cpi, calculator at: http://www.minneapolisfed.org/

(11) Every HHC 2010 attendee received a copy of this booklet with their conference proceedings because it a rare tutorial on Classical RPN. The manual printing cost was kept low by having the majority of the pages of the "E" series manuals in the 56 page "Solving Problems with Your Hewlett-Packard Calculator" which could be printed in larger quantities. The specific details of each model were in the much fewer pages individual model manuals.

(12) See ***HP Solve*** *Issue 16, "The HP-41 system – 30 years old" for a detailed description of this most popular HP calculator that continues to be "improved" even as this is being written. The HP-41 provided so many firsts (that are explained in the article) because it was a revolutionary leap in technology.*

(13) One of the best sites for HP calculator usage (all models) in space is at: http://hpinspace.wordpress.com/

(14) Synthetic Programming, SP, is the use of HP-41 synthetically assembled instructions that cause the machine to perform "illegal" operations. The PPC ROM User's Manual is the best place to start if you want to become familiar with the subject because SP is explained along with programs that will assist in the generation of the many synthetic instructions that are possible. An example of this power is machine-perfect Morse code. I wrote an HP-41 program that was published in the PPC Calculator Journal, February 1980 issue on page 50. Even using synesthetic tones the speed was limited to 6 words per minute. A more sophisticated SP technique of addressing memory produces a speed of 16 words per minute. A discussion of the technique to do this may be found in Keith Jarett's © 1982 book HP-41 Synthetic Programming Made Easy, page 151. The program in bar code is on page 183.