
# OWNER'S MANUAL

DRAFT

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## WELCOME

Dear user, you hold in your hands the result of careful customizing. Mechanics and hardware of your WP 34S are of the new *HP-30b Business Professional* as is: so you get its unexcelled processor speed as well as the famous rotate-and-click keys with the tactile feedback known and appreciated in vintage Hewlett-Packard calculators for decades. On the other hand, the firmware and user interface of the WP 34S are newly designed and written from scratch to give you a **fast and compact scientific calculator like you have never had before**.

The function set of the WP 34S is based on the one of the renowned *HP-42S RPN Scientific*, the most powerful programmable RPN calculator built so far [1]. We expanded this set, completely incorporating the functionality of the famous programmer's calculator *HP-16C*, fraction mode of the *HP-32SII*, probability distributions as featured by the *HP-21S*, and **many more useful functions for mathematics, statistics, physics, engineering, programming etc.** like

- Euler's Beta function, Fibonacci number calculation, Lambert's W (all of these in the real and complex domains), incomplete regularized Beta and Gamma, the most 'popular' orthogonal polynomials, testing for primality,
- the error function as well as many statistical distributions and their inverses like Poisson, Binomial, Cauchy-Lorentz, Logistic, Geometric as well as Exponential, Weibull for reliability analysis, Lognormal and Gaussian with arbitrary mean and standard deviation,
- programmable sums and products,
- extended date and time calculations based on a real time clock,
- integer computing in arbitrary bases from binary to hexadecimal,
- financial operations like mean rate of return and margin calculations,
- over 70 conversions, mainly between universal SI and old Imperial units,
- nearly 50 fundamental physical constants as precise as known today by national standards institutes like NIST or PTB,
- complete Greek and extended Latin letter fonts covering many languages (upper and lower case in two font sizes each).

**The WP 34S is the first RPN calculator overcoming the limits of a 4-level stack** – forget worries about stack overflow in calculations. It features a choice of two stack sizes expanded by a complex LASTx register: traditional 4 stack levels for HP compatibility, 8 levels for convenient calculations in complex domain, for more advanced real formulas, or for whatever application you have in your mind. You get a full command set for navigation in either size.

Furthermore, the WP 34S features over 100 general purpose registers, 100 user flags, 476 program steps, 3 programmable hotkeys for your favorite programs, and a 31 byte alpha register for message generation.

[1] Though the *HP-42S* was sold in 1988 already, this statement holds still. – Due to display restrictions, matrix math cannot be supported by the WP 34S. Sorry for this.


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If you know how to deal with a good old HP RPN calculator, you can start with your WP 34S right away. To show you its features completely, however, we wrote this little manual. It starts with a survey of the active keyboard in various modes, so you know where to find what you are looking for. It continues with tables about addressing, browsing the catalogs, and a paragraph about the display and indicators used to tell you what's going on. Then the major part of this booklet is taken by the index of operations, the catalog contents, constants and conversions featured. It closes with a list of messages the WP 34S will display if special input conditions prevent it from executing your command as expected.

Your WP 34S is the result of an intercontinental collaboration of two individuals, an Australian and a German. We did this in our free time, so you may call it our hobby to some extent. The project was discussed in the online Museum of HP Calculators (*www.hpmuseum.org*) from its beginning, so we want to express our gratitude to all contributors there who taught us a lot and supported us in several stages of our project. Special thanks go to Marcus von Cube supporting us in bringing to life v1.14 in an emulator and the current version on your screen so you can use it. We baptized it 34S in honor of one of the most powerful LED pocket calculators, the *HP-34C*, and since it is our humble approach – with the hardware given – to a future 43S we can only dream of becoming the successor of the *HP-42S*. Maybe it will help convince those having access to more resources than us that it is worthwhile covering the market of serious scientific instruments.

We have checked everything we could think of carefully to our best knowledge, so our hope may be justified the WP 34S is bug-free. We cannot guarantee this, however, nor can we bear any liability for errors in calculations nor their possible consequences. Nevertheless, we promise we will improve the WP 34S whenever it turns out being necessary – so if you ever discover any strange result, please report it to us, and if it is revealed to be an internal error we will provide you with an update as soon as we have one.

Enjoy!

*Paul Dale and Walter Bonin*

**PRINT CONVENTIONS**

Throughout this manual, commands are generally called by their names, usually written in CAPITALS.

This **CPX** font is taken for explicit references to keys.

Register addresses are printed using Times New Roman. Lower case italic letters of this font are reserved for register contents (e.g. ***y*** or ***r45*** or ***alpha*** for contents of stack level **Y** or general purpose register **R45** or the alpha register, respectively). Lower case bold italic Arial letters like ***n*** are used for variables.

All this holds unless stated otherwise explicitly.

## KEYBOARD


Generally, white labels execute the *default primary function* of the respective key. To access a golden, blue, or green label, use *prefix* f, g, or h, respectively. Any label underlined opens a *catalog*. For example, → preceded by

- f executes R◄ converting 2D polar coordinates ***r*** in **X** and $\vartheta$ in **Y** into Cartesian ones, allowing also for switching representations of complex numbers,
- g does the reverse, i.e. converts ***x*** and ***y*** into ***r*** and $\vartheta$ via ►P ,
- h opens the catalog of conversions via CONV .
- The dark red letter **E** will become relevant in *alpha mode* as well as in integer modes of bases 15 and 16. Find out more about these and other modes below.

Further remarks:

- The *hotkeys* B, C, and D immediately call the user programs carrying these labels if defined, else they act as 1/x, $y^x$, or √x, respectively.
- The key ➡ trailed by H.MS, H.d, DEG, RAD, GRAD, 2, 8, 10, or 16, converts ***x*** .
- If . is used twice in numeric input, the WP 34S enters fraction mode.
- Prefix CPX is employed for calling functions in complex domain. Their name will be headed by the complex symbol, e.g. CPX f COS will be displayed and listed as $^{C}$COS. All complex functions in WP 34S operate on Cartesian coordinates exclusively. Generally, if an arbitrary real function **f** operates on …
  - ***x*** only, then its complex sibling $^{C}$**f** will operate on $x_c = x + i\,y$ .
  - one register, e.g. **R12**, then $^{C}$**f** will operate on **R12** and **R13**.
  - ***x*** and ***y***, then $^{C}$**f** will operate on ***x, y, z*** and ***t*** .
- Most one-number real functions replace ***x*** by the result **f(*x*)** stored in X again. By analogy, one-argument complex functions replace ***x*** by the real part and ***y*** by the imaginary part of the complex result $^{C}\mathbf{f}(x_c)$ . Higher stack levels remain unchanged. Such functions are $^{C}$1/x, $^{C}$ABS, $^{C}$FIB, $^{C}$FP, $^{C}$IP, $^{C}$ROUND, $^{C}$SIGN, $^{C}$W, $^{C}W^{-1}$, $^{C}$x!, $^{C}x^2$, $^{C}$√‾, $^{C}$**+/–**, $^{C}$Γ(x), logarithmic and exponential with bases 10, 2 and e, as well as hyperbolic, trigonometric, and their inverses.

  Some real functions (e.g. DECOMP) operate on one number but return two. Other operations (like RCL or SUM) do not consume any stack input at all but just return one or two numbers. Then these extra number(s) will be pushed on the stack, taking one level per real or two per complex number.
- Two-number real functions replace ***x*** by the result **f(*x, y*)** . Level **Y** is then filled with the content of the next higher level, i.e. ***z*** . This goes on for higher levels, only the number on top of the stack is repeated as shown below.

  Analogously, two-argument complex functions replace ***x*** by the real part and ***y*** by the imaginary part of the complex result $^{C}\mathbf{f}(x_c, y_c)$ . The next stack levels are filled with the complex contents of higher levels, and the complex number in the top two stack levels is repeated as shown below. Such complex functions are $^{C}LOG_X$, $^{C}y^x$, $^{C}$β(x,y), $^{C}$// , and the basic arithmetic operations in complex domain.
- There are 3 three-number real functions included – Iβ, $L_n\alpha$ and %MRR – replacing ***x*** by the result **f(*x, y, z*)** . Then **Y** is filled with ***t*** and so on, and the content of the top level is repeated twice. No such complex functions are featured.

Please see the *index of operations* for a complete list of all the operations provided.



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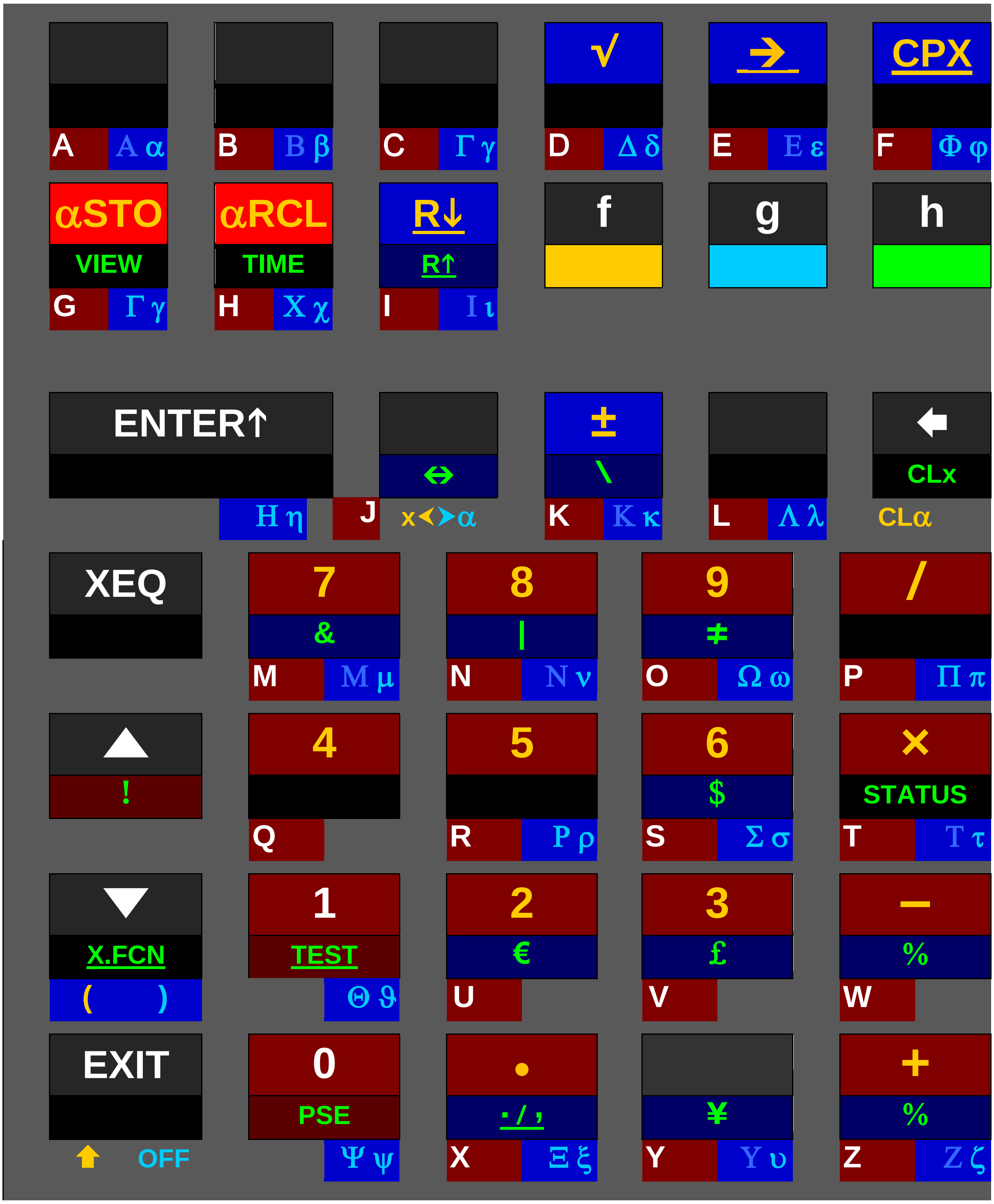
Virtual active keyboard in **hexadecimal mode**:

Primary functions of the top six keys will be numeric input, so their default primary functions are accessed using f . The key → is exclusively for addressing and temporary display in other bases (see addressing tables and index of operations below).

For smaller integer bases, the active keyboard will look similar, but those top keys not needed for numeric input will keep their default primary functions, except Σ+ and CPX . Attempts to enter an illegal digit will be blocked or throw an error.

Virtual active keyboard in **alpha mode:**



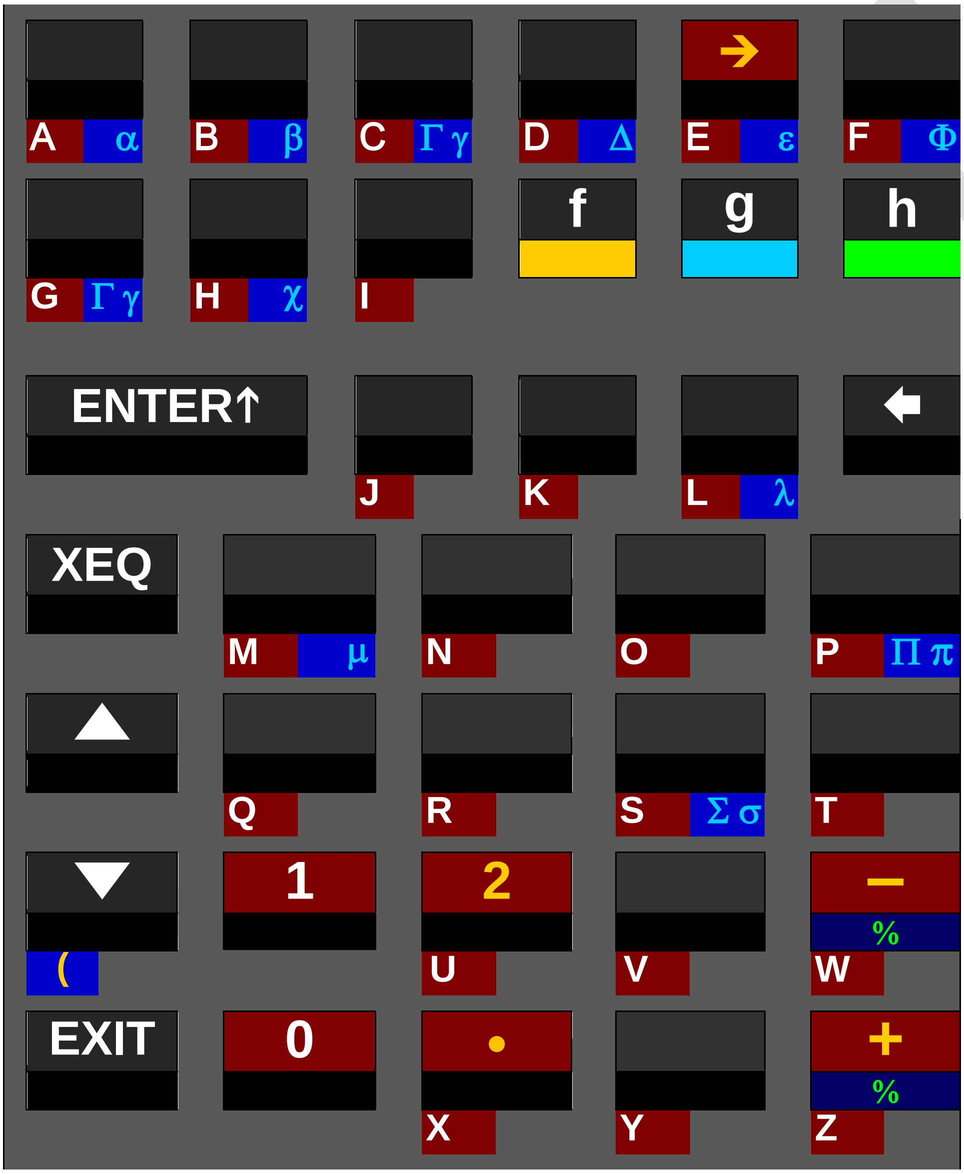
In this mode, the alpha register is displayed in the dot matrix, and the numeric line is accessible by commands only. All labels printed on dark red or blue background in this picture append characters to ***alpha*** immediately or via alpha catalogs; those on blue deviate from the labels on the WP 34S keyboard at these locations.

Alpha mode starts in upper case, and ⇧ toggles upper and lower case. PSE appends a space. The primary function of most keys is appending the letter printed bottom left of this key – dark red on the key plate. Prefix f is used for accessing the default primary functions there [2], and **g** leads to homonymic Greek letters where applicable [3]. Prefix **h** gives access to some logic symbols via the Boolean operations. Four currency symbols are located next to the %-sign as follows: **$** at the letter S, **€** at U for Euro, **£** at π, and **¥** at Y for Yen or Yuan. The catalogs **f** **→**, **f** **CPX**, **f** **R↓**, **h** **R↑**, **h** **TEST**, and **h** **./,** feature even more characters (see *below*).

When ***alpha*** exceeds 31 characters, the leftmost character(s) are discarded.

See the *index of operations* for αSTO, αRCL, αTIME, and more alpha commands.

A subset of these characters is sufficient for **browsing an open catalog:**




Please note **f** **→** will just call the character → while browsing a catalog.

**▲** and **▼** step through the catalog, **XEQ** or **ENTER↑** select the item shown, and **EXIT** will leave the catalog without picking anything. See *below* for some examples.

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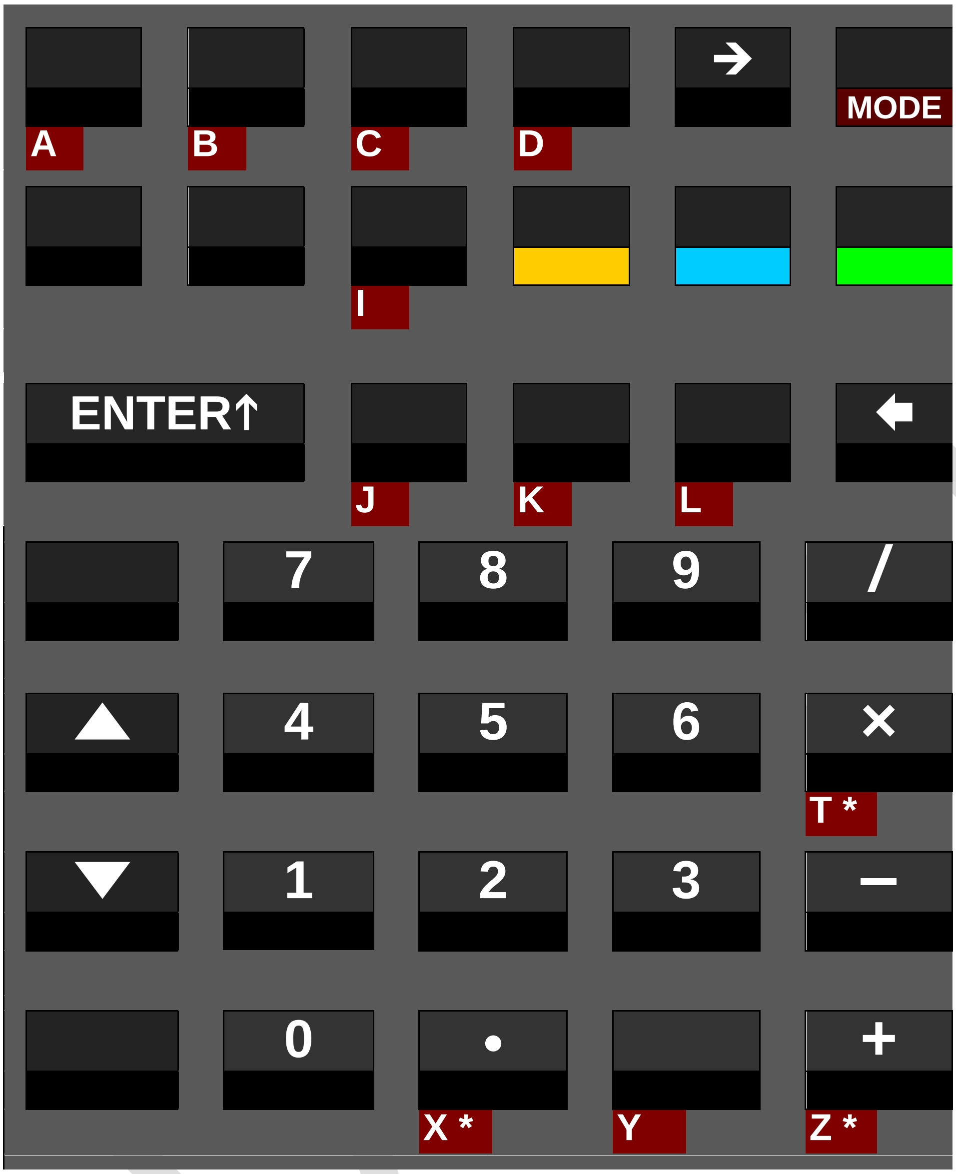
[2] The digits 0 and 1 may also be called using **f** **0** or **f** **1**, respectively.

[3] "Homonymic" according to ancient Greek pronunciation. And we assigned **Gamma** also to **C** due to the alphabet, and **Chi** to **H** since this letter comes next in pronunciation. Three Greek letters require special handling: **Psi** is accessed via **g** **0** (below **PSE**), **Theta** via **g** **1** (below **TEST** and following **T**), and **Eta** via **g** **ENTER↑**. **Omicron** is not featured since looking exactly like **O** in either case. – Where we printed Greek capitals with lower contrast on page 7, they look like the respective Latin letters in our fonts. Greek professors, we count on your understanding.

A **<u>temporary alpha</u> mode** is entered during input processing in comparisons and addressing, e.g. during storing and recalling. See the respective virtual active keyboard here:




This mode is left automatically when sufficient characters are put in for the respective command. Find more about it below.

In this mode, $\boxed{.}$ is employed for ENG, FIX, and SCI only (see below).

# MEMORY

**Stack registers**

| | |
|---|---|
| | D * |
| | C * |
| | B * |
| | A * |
| | T |
| Alpha (31 bytes) | Z |
| | Y |
| Display | X |

| | |
|---|---|
| L | I ** |

**General purpose registers**

| |
|---|
| R00 |
| R01 |
| R02 |
| … |
| |
| … |
| R85 |
| R86 Σ ($x^2$ *y*) |
| R87 Σ *x* |
| R88 Σ $x^2$ |
| R89 Σ *y* |
| R90 Σ $y^2$ |
| R91 Σ (*x y*) |
| R92 *n* |
| R93 Σ (ln *x*) |
| R94 Σ (ln² *x*) |
| R95 Σ (ln *y*) |
| R96 Σ (ln² *y*) |
| R97 Σ(lnx lny) |
| R98 Σ (*x* ln *y*) |
| R99 Σ (*y* ln *x*) |

| |
|---|
| J *** |
| K *** |

**User flags**

| |
|---|
| 00 |
| 01 |
| 02 |
| … |
| |
| … |
| 97 |
| 98 |
| 99 |

**Program steps**

| |
|---|
| 000 |
| 001 |
| 002 |
| … |
| |
| … |
| 473 |
| 474 |
| 475 |

**User readable system flags**

| |
|---|
| B *Big, overflow* |
| C *Carry* |
| D *Danger* |

| |
|---|
| X = R100 |
| Y = R101 |
| Z = R102 |
| T = R103 |
| A = R104 |
| B = R105 |
| C = R106 |
| D = R107 |
| L = R108 |
| I = R109 |
| J = R110 |
| K = R111 |

For the first time ever in a calculator, the WP 34S offers a choice of 4 or 8 stack levels. So either **T** or **D** will be the top level. Registers **A - D** will be allocated as stack registers if required.

Please see *below* for top level repetition and stack contents in complex calculations. While register **L** takes the real part of the last argument, **I** takes the imaginary part when a complex function was executed (see $^{C}$LASTx).

After using $\boxed{\Sigma+}$, general purpose registers **R87 - R99** will contain statistical sums as indicated. **J** and **K** may be taken for parameters of statistical distributions.

Unless required for the purposes just mentioned, the registers **A - D, I, J,** and **K** are available as additional general purpose registers.

System flags **B** and **C** are handled like in the *HP-16C*. Flag **D** is set if legal results include "NaN" and "infinite".

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## STACK MECHANICS

What happens with the contents of particular stack levels depends on the function executed, its domain (integer, real or complex) and the stack size chosen.

Real functions in a 4-level stack work as known for decades. In a larger stack, everything works alike on the WP 34S – just with more levels for intermediate results. Calculating formulas from inside out stays a wise strategy in either stack. With more levels, however, stack overflow will hardly ever happen, even with the most advanced formulas you compute in your life as a scientist or engineer.

Calculating with complex numbers uses two registers or levels for each such number as explained above and shown here:

| | Level | Assumed stack contents at the beginning: | Stack contents after executing … … the complex stack register operations $^{C}$ENTER, $^{C}$FILL | | $^{C}$DROP | $^{C}$x↔y, $^{C}$R↓, $^{C}$R↑ | | | $^{C}$LASTx | … complex functions of … 1 number like $^{C}x^2$ | … 2 numbers like $^{C}$/ | … integer or real functions of 2 numbers like / Before | After |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| With SSIZE4: | T | Im($y_c$) = Im($t_c$) | Im( $x_c$ ) | | $y_c = t_c$ | $x_c$ | | | $x_c$ | $y_c = t_c$ | $y_c = t_c$ | $t$ | $t$ |
| | Z | Re($y_c$) = Re($t_c$) | Re( $x_c$ ) | | | | | | | | | $z$ | $t$ |
| | Y | Im( $x_c$ ) | Im( $x_c$ ) | | $y_c$ | $y_c$ | | | $lastx_c$ | Im( $(x_c)^2$ ) | Im( $y_c / x_c$ ) | $y$ | $z$ |
| | X | Re( $x_c$ ) | Re( $x_c$ ) | | | | | | | Re( $(x_c)^2$ ) | Re( $y_c / x_c$ ) | $x$ | $y / x$ |
| With SSIZE8: | D | Im( $t_c$ ) | $z_c$ | $x_c$ | $t_c$ | $t_c$ | $x_c$ | $z_c$ | $z_c$ | $t_c$ | $t_c$ | $d$ | $d$ |
| | C | Re( $t_c$ ) | | | | | | | | | | $c$ | $d$ |
| | B | Im( $z_c$ ) | $y_c$ | $x_c$ | $t_c$ | $z_c$ | $t_c$ | $y_c$ | $y_c$ | $z_c$ | $t_c$ | $b$ | $c$ |
| | A | Re( $z_c$ ) | | | | | | | | | | $a$ | $b$ |
| | T | Im( $y_c$ ) | $x_c$ | $x_c$ | $z_c$ | $x_c$ | $z_c$ | $x_c$ | $x_c$ | $y_c$ | $z_c$ | $t$ | $a$ |
| | Z | Re( $y_c$ ) | | | | | | | | | | $z$ | $t$ |
| | Y | Im( $x_c$ ) | $x_c$ | $x_c$ | $y_c$ | $y_c$ | $y_c$ | $t_c$ | $lastx_c$ | $(x_c)^2$ | $y_c / x_c$ | $y$ | $z$ |
| | X | Re( $x_c$ ) | | | | | | | | | | $x$ | $y / x$ |

So, an 8-level stack gives you the same flexibility in complex domain you are used to with a 4-level stack in real domain.

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## COMPARING AND ADDRESSING REAL NUMBERS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | User input | x= ?, x≠ ?, x< ?, x≤ ?, x≈ ?, x≥ ?, or x> ? | | | | RCL, STO, RCLS, STOS, αRCL, αSTO, VIEW, x⇄, DSE, ISG, DSZ, ISZ, FIX, SCI, ENG, DISP, BASE, CB and many more bit commands, or CF and the other flag commands etc. | | | |
| | Dot matrix display | **OP** _ (with temporary alpha mode set), e.g. x> _ | | | | **OP** _ (with temporary alpha mode set), e.g. RCL _ [4] | | | |
| 2 | User input | 0 or 1 | *Stack level or named reg.* X, Y, … | ENTER↑ [5] leaves temp. alpha mode. | → opens indirect addressing. | *Stack level or named register* X, Y, Z, .. , K [6] | ***Number** of register or flag or bit(s) or decimals* [7] | → opens indirect addressing. | |
| | Dot matrix display | **OP *n*** e.g. x≤ 0 ? | **OP *x*** e.g. x≥ y ? | **OP r_** | **OP →_** | **OP *x*** e.g. SCI Z | **OP *nn*** e.g. SF 15 | **OP →_** | |
| 3 | User input | Compares ***x*** with the number **0.** | Compares ***x*** with the number on stack level **Y.** | *Register no.* 00 … 99 | Look right for more about indirect addressing. | Sets scientific display with the number of decimals specified in stack level **Z.** | | *Stack level etc.* X, Y, Z, … , K | *Register number* 00 … 99 |
| | Dot matrix display | | | **OP r *nn*** e.g. x≠ r23? | | | | **OP → *x*** e.g. VIEW →L | **OP → *nn*** e.g. STO →45 |
| | | | | Compares ***x*** with the number stored in **R23.** | | | | Shows the content of the register where **L** is pointing to. | Stores ***x*** into the location where **R45** is pointing to. |

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[4] For RCL and STO, any of +, −, ×, /, ▲, or ▼ may precede step 2, except in RCLM and STOM. FIX . calls ALL. ENG . calls ENGOVR. SCI . calls SCIOVR. See the index of operations.

[5] You may skip this for register numbers >19.

[6] Exceptions: RCL T, RCL× T, RCL Z, RCL+ Z require an ENTER↑ previous to T or Z, e.g. RCL + ENTER↑ Z for the latter. This holds for STO as well.

[7] Register and flag numbers may be 00 … 99, number of decimals 0 … 11, integer bases 2 … 16, bit numbers 0 to 63, and integer word size up to 64 bits. For numbers <10, you may key in e.g. 5 ENTER↑ instead of 0 5 . There are three additional flags addressed via B, C, and D . – Take into account some registers may be allocated to special applications.



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## COMPARING AND ADDRESSING COMPLEX NUMBERS

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | User input | CPX x= ? or x≠ ? | | | | CPX RCL, STO, or x⇄ | | |
| | Dot matrix display | **OP _** (with temporary alpha mode set)<br>e.g. ▪x= _ | | | | **OP _** (with temporary alpha mode set)<br>e.g. ▪RCL _ [8] | | |
| 2 | User input | 0 or 1 | *Stack level or named register*<br>X, Z, A, C,<br>L, or J | ENTER↑ [9]<br>leaves temp. alpha mode | →<br>opens indirect addressing. | *Stack level or named register*<br>Z [10], A, C,<br>L, or J | *Register number*<br>0 0 .. 9 8 [11] | →<br>opens indirect addressing. |
| | Dot matrix display | **OP *n***<br>e.g. ▪x= 0 ? | **OP *x***<br>e.g. ▪x≠ z ? | **OP r_** | **OP →_** | **OP *x***<br>e.g. ▪RCL L | **OP *nn***<br>e.g. ▪STO 18 | **OP →_** |
| 3 | User input | Compares ***x*** + *i* ***y*** with the real number **0**. | Compares ***x*** + *i* ***y*** with ***z*** + *i* ***t*** . | *Register number*<br>0 0 … 9 8 | Look right for more about indirect addressing. | This is $^C$LASTx. | *Stack level or named register*<br>X, Y, ... , K | *Register number*<br>0 0 … 9 9 |
| | Dot matrix display | | | **OP r *nn***<br>e.g. ▪x≠ r26? | | | **OP → *x***<br>e.g. ▪x<> →Z | **OP → *nn***<br>e.g. ▪STO →45 |
| | | | | Compares ***x*** + *i* ***y*** with ***r26*** + *i* ***r27*** . | | | Swaps ***x*** with the contents of the register where **Z** is pointing to, and ***y*** with the contents of the next one. | Stores ***x*** + *i* ***y*** into 2 consecutive registers, starting with the one where **R45** is pointing to. |

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[8] For RCL and STO, any of +, −, ×, or / may precede step 2. See the index of operations.

[9] You may skip this keystroke for register numbers >19.

[10] Exceptions: $^C$RCL Z, $^C$RCL + Z, $^C$STO Z, and $^C$STO + Z require an ENTER↑ previous to Z, e.g. CPX STO + ENTER↑ Z for the latter.

[11] You may key in e.g. 8 ENTER↑ instead of 0 8 . Take care of pairs, since a complex operation will always affect two registers: the one specified and the one following this. We strongly recommend storing complex numbers with their real parts at even register numbers. – Take into account some registers may be allocated to special applications.

## ADDRESSING LABELS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | User input | B, C, or D | XEQ, GTO, LBL, LBL?, SLV, ∫, π or Σ | | | | |
| | Dot matrix display | **XEQ '*label*'** e.g. `XEQ 'C'` | **OP _** e.g. `GTO _` | | | | |
| 2 | User input | Calls the function labeled **C**. | B, C, or D | ENTER↑ sets alpha mode. | → [12] opens indirect addressing and sets temporary alpha mode. | | *2-digit numeric label* 0 0 … 9 9 |
| | Dot matrix display | | **OP '*label*'** e.g. `Σ 'B'` | **OP '_** | **OP →_** | | **OP *nn*** e.g. `LBL 07` |
| 3 | User input | | Sums up the function labeled **B**. | ***Alphanumeric label*** (≤ 3 characters [13]) | *Stack level or named register* X, Y, Z, … , K | *Register number* 0 0 … 9 9 [14] | |
| | Dot matrix display | | | **OP '*label*'** e.g. `SLV'F1µ'` | **OP → *x*** e.g. `∫ →T` | **OP → *nn*** e.g. `XEQ →44` | |
| | | | | Solves the function **F1µ** (with **F1µ** keyed in as explained in footer). | Integrates the function whose label is on stack level **T**. | Executes the routine whose label is in **R44**. | |

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[12] Works with all these operations except LBL .

[13] The 3rd character terminates entry and closes alpha mode – shorter labels need a closing ENTER↑. For the example given here you just key in f 2 ENTER↑ CPX 1 f EXIT g 7 and you are done.

[14] Some registers may be allocated to special applications. Please check the memory table above.

## ADDRESSING CATALOG ITEMS

| | | | | |
|---|---|---|---|---|
| 1 | User input | CONST, CONV, MODE, PROB, P.FCN, STAT, TEST, or X.FCN | CPX, R↓, or R↑ in alpha mode | →, TEST, or ./, in alpha mode |
| | Dot matrix display | **Shows $1^{st}$ item in selected catalog.**<br>(e.g. BC? in P.FCN)<br>Alpha mode is set. | (e.g. Á in CPX) | (e.g. , in ./,) |
| 2 | User input | XEQ, ▼, ▲, EXIT, or $1^{st}$ character<br>(e.g. F) | XEQ, ▼, ▲, EXIT, or character<br>(e.g. O) | |
| | Dot matrix display | **Shows $1^{st}$ item starting with this character *)**<br>(e.g. FB) | **Shows $1^{st}$ item starting with this letter *)**<br>(e.g. Ó) | |
| 3 | User input | XEQ, ▼, ▲, EXIT, or $2^{nd}$ character<br>(e.g. S) | | |
| | Dot matrix display | **Shows $1^{st}$ item starting with this sequence *)**<br>(e.g. FS?) | | |
| 4 | User input | XEQ , ▼ , ▲ , or EXIT<br>(e.g. ▼) | | |
| | Dot matrix display | **Shows next item in this catalog**<br>(e.g. FS?C) | (e.g. Ò) | (e.g. ?) |
| … | | Continue browsing this way until reaching the item desired<br>(e.g. FS?F). | (e.g. Ö). | (e.g. :). |
| n | User input | XEQ<br>Calculator leaves the catalog returning to the mode set before | | |
| | Dot matrix display | … and executes or inserts the command chosen, or recalls the constant selected.<br>**Result** | … and appends the selected character to ***alpha***.<br>**Contents of alpha register**<br>(e.g. Ostl. Seite:) | |

*) If a character or sequence specified is not found in this catalog then the first item following alphabetically will be shown. You may key in more characters – within 3 seconds. Thereafter or after ▼ or ▲ , the search string will be reset and you may start with a first character again.

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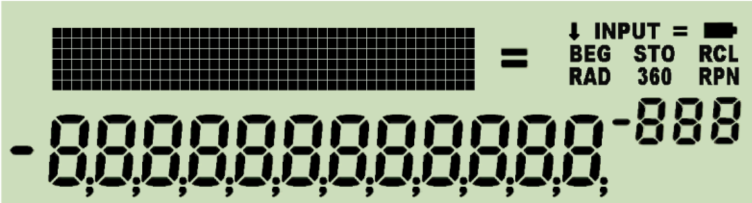
## DISPLAY

The display features three sections: numeric, dot matrix and fixed symbols. The numeric section features a minus sign and 12 digits for the mantissa, as well as a minus sign and 3 digits for the exponent. The dot matrix is 6 dots high and 43 dots wide, allowing for some 7 to 12 characters, depending on their widths. The fixed symbols (except the big "=") are called *annunciators*, and are for indicating modes.




The dot matrix section above is used for

1. indicating some more modes than the annunciators allow,
2. passing additional information to the user.

The numeric section in the lower part of the LCD is used for displaying numbers in different formats, status, or messages.

If two or more requests concur for display space, the items will be shown according to their priorities as follows:

1. error messages as described in a paragraph further below,
2. special information as explained below,
3. information about the modes the calculator is running in.

The *annunciators* or specific characters in the display signal the modes:

| **Signal** | ***INPUT*** | **b** | **d** | **h** | **o** | |
|---|---|---|---|---|---|---|
| **Mode name if different** | **α** | **2** | | | **8** | **DECM** |
| **Set by …** | αON | BASE2 | BASE10 | BASE16 | BASE8 | BASE0 |
| **Cleared by …** | αOFF | any other BASE setting, FRACT, IMPFRC, PROFRC. FIX, SCI, ENG, H.MS, TIME, →H.MS will set DECM | | | | |

| **Signal** | ***STO*** | ***360*** | ***RAD*** | **G** | |
|---|---|---|---|---|---|
| **Mode name if different** | **PRG** | | | | **FRC** |
| **Set by …** | PRGON | DEG | RAD | GRAD | BASE1, FRACT<br>IMPFRC, PROFRC<br>2nd [.] in input |
| **Cleared by …** | PRGOFF | GRAD<br>RAD | DEG<br>GRAD | DEG<br>RAD | BASE ≠ 1<br>H.MS, TIME, →H.MS<br>FIX, SCI, ENG |

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***BEG*** indicates the program pointer standing at step 000 of program memory. A running program is signaled by a flashing ***RCL*** annunciator. The small equal sign **=** is lit while you are browsing a catalog. ***RPN*** may be lit permanently. Time modes (12h / 24h) are seen in the time string directly. The numeric format of fraction mode is unambiguous as well. Further settings are signaled in the dot matrix section, like the different date modes being indicated there by **D.MY** or **M.DY**. Defaults Y.MD and DECM are not indicated. Please check the examples below.

Some mode and display settings may be stored and recalled collectively by STOM and RCLM. The command RCLM recalls a 18-bit word containing mode data packed as follows, starting with the least significant bit:

| Bits | Meaning | Values and corresponding settings | | |
|---|---|---|---|---|
| 0, 1 | Display format for real numbers | 0 = ALL<br>2 = SCI | 1 = FIX<br>3 = ENG | |
| 2 … 5 | Number of decimals | 0 … 12 | | |
| 6, 7 | Angular mode | 0 = DEG | 1 = RAD | 2 = GRAD |
| 8, 9 | Date display format | 0 = Y.MD | 1 = D.MY | 2 = M.DY |
| 10 | Time display format | 0 = 24h | 1 = 12h | |
| 11 | Radix mark | 0 = point | 1 = comma | |
| 12 … 14 | Curve fit model | 0 = LinF<br>2 = PowerF | 1 = ExpF<br>3 = LogF | <br>4 = BestF |
| 15, 16 | Integer sign mode | 0 = 2COMPL<br>2 = UNSIGN | 1 = 1COMPL<br>3 = SIGNMT | |
| 17 | Stack depth | 0 = 4 levels | 1 = 8 levels | |

So the start-up default with 4 stack levels, ALL, DEG, Y.MD, 24h, decimal point, LinF, and 2COMPL is zero. On the other hand, settings for e.g. 8 stack levels, SCI 2, RAD, D.MY, 12h, decimal comma, BestF, UNSIGN correspond to

$$110100110101001010_2 = 445770_{10} .$$

STOM takes such a number and sets the calculator modes accordingly. Please see the *index of operations* for more information about changing modes.

Some commands and modes use the display in a special way. They are listed below in order of falling priority:

1. **VERS** generates a display as shown on the title page of this manual. Pressing any key will delete this message and return to previous state.

2. **STATUS** displays the status of 30 flags very concisely, allowing an immediate status overview after some training. If e.g. flags 2, 3, 5, 7, 11, 13, 14, 17, 19, and 23 are set, and labels B, C, and D are defined in program memory, STATUS will display this:


Within the numeric section, each row of horizontal bars in the mantissa shows the status of 10 flags. When a flag is set, the respective bar turns black. So here the top row of bars indicates flags 0 and 1 are clear, 2 and 3 set, and flag 4 clear. Then, the divider II separates the first group of five flags from the next. Top row bars on its right side indicate flags 5 and 7 are set. Next row of bars shows flags 11, 13, 14, 17, 19 are set, and in the lowest row only flag 23 is set. All other flags in the range from 10 to 29 are clear.

Scrolling down by ▼ will display flags 10 - 39, then 20 - 49 etc. until 80 - D. Scrolling up by ▲ reverts this. Alternatively, pressing a digit, e.g. 5, will show 30 flags starting with 10 times this digit, e.g. flags 50 - 79. The numeric exponent always indicates the status of the 3 hotkeys top left on the keyboard.

The status will be displayed until any key is pressed but ▼, ▲, or a digit < 9.

3. During **command input**, the dot matrix displays the command chosen until input is completed, i.e. until all required trailing parameters are entered. The prefixes f, g, and h are shown until they are resolved. If you pressed any of f, g, or h erroneously, recovery is as easy as follows:

   - f f = NOP = g g = h h = CPX CPX = → →
   - g f = h f = f<br>f g = h g = g<br>f h = g h = h

   In addressing, progress is recorded as explained in the *addressing tables above* in detail.

4. In **programming mode**, the numeric display indicates the program step (000 – 475) in the mantissa and the number of free steps in the exponent, while the dot matrix shows the command contained in the respective step, e.g.:


5. For **floating point decimal numbers**, the mantissa will be displayed adjusted to the right, the exponent to the left. Within the mantissa, either points or commas may be selected as radix marks [15], and additional marks may be chosen to separate thousands. Assume the display set to FIX 4, then 12.345678901 millions may look like:

[15] Starting here, decimal input is written using a point as radix mark throughout this manual, although significantly less visible, unless specified otherwise explicitly. By experience, the „comma people“ are more capable to read radix points and interpret them correctly than vice versa.

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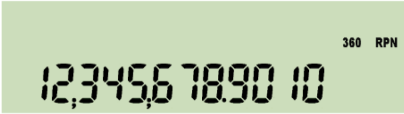
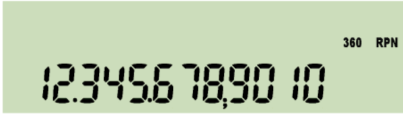
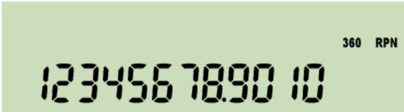


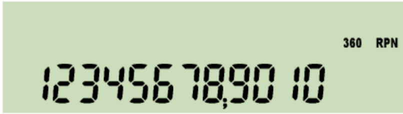

or



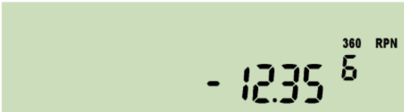

with thousands separators on, and without them like:



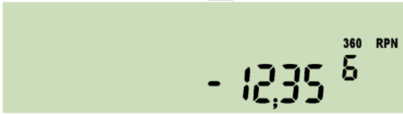

or




These separators may also be beneficial in integer or fraction modes described below. – With ENG 3 and after changing the sign, the same number will look like this:




or




If the last operation executed was a complex one, a capital C is displayed top left in the dot matrix pointing to the fact that you find the result of this function in **X** and **Y**.

Floating point decimal numbers within $10^{-383} < x < 10^{+385}$ may be entered easily. Using a decimal mantissa, even numbers down to $10^{-394}$ can be keyed in. The calculator works with numbers down to $10^{-398}$ correctly. Smaller nonzero values are shown as $0^{-398}$. For results $x \geq 10^{+385}$, error 4 or 5 will appear (see below).

6. In **integer modes**, numbers are displayed adjusted to the right as well. Word size and complement setting are indicated in the dot matrix using a format ***xx.ww***, with ***xx*** being **1c** or **2c** for 1's or 2's complement, respectively, **un** for unsigned, or **sm** for sign-and-mantissa mode. Sign and first digit of the exponent show the base, a "c" in the second digit signals a carry bit set, an "o" in the third an overflow. Integer bases are indicated as follows:

| Base | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sign and 1st digit of exponent displayed | **b** | **3** | **4** | **5** | **6** | **7** | **o** | **9** | **d** | **-1** | **-2** | **-3** | **-4** | **-5** | **h** |

The example shows the WP 34S in unsigned hexadecimal mode with word size 64 and carry set:


After changing to binary mode, this number will need 28 digits, being 1001001110100001010010110110. Initially, the 12 least significant digits will be displayed together with an indication that there are three display windows in total with the rightmost shown:


Now press ◀ and you will get the next 12 digits in the middle window:

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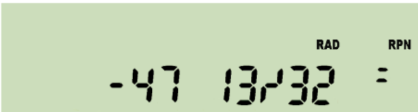
Press ◀ again to show the most significant digits:

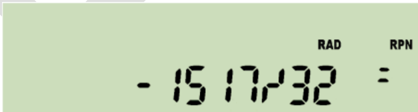

If leading zeros were turned on, there will be six display windows in this case, with the three "most significant" containing only zeros.

Please note the window will also change in numeric entry when more than 12 digits are keyed in. Leftmost digits will leave the display window then.

7. **Fraction mode** works similar to HP-35S. In particular, DENMAX sets the maximum allowable denominator (see the *index of operations*). Display will look like in the examples below. If the fraction is exactly equal, slightly less, or greater than the floating point number converted, "=", "Lt", or "Gt" is indicated in the exponent, respectively.

   Assume DENMAX ≥ 32. Then e.g. -47.40625 will be displayed as follows:

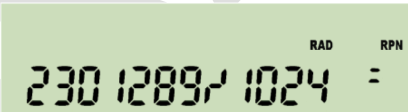
   

   or
   

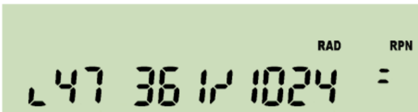

   depending on the output setting for proper or improper fractions. Please note integers like 123 will be displayed as "123 0/1" or "123/1" in fraction mode, respectively.

   Fraction mode can handle numbers with absolute values < 10,000 and > 0.0001. Maximum denominator is 9999.

   Using DENMAX = 9999, squaring the improper fraction shown above results in

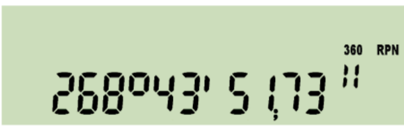

   Now, enter a b/c for converting this result into a proper fraction. Your 34S will display


   with a little hook left of the first digit shown. This indicates the first number being displayed incompletely – there are at least two digits preceding 47 but no more display space. Press SHOW to unveil the integer part of this proper fraction is 2247.

8. In **H.MS display mode**, format is `hhhh°mm'ss.dd"` with the number of hours or degrees limited to 9000. Output may look like this:

   or
   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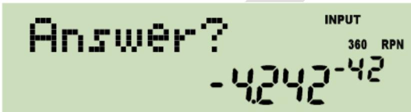
depending on the radix setting. For decimal times less than 5ms or 0.005 angular seconds but greater than zero, an “u” for underflow will be lit in the exponent section. For times or angles exceeding the upper limit, an “o” will be shown there signaling an overflow, and the value is displayed modulo 9000.

9. Output of the function **DAY** will look as follows for an input of 1.13201 in M.DY mode (equivalent to inputs of 13.01201 in D.MY or 2010.0113 in Y.MD):


The display may look similar for a result of DAYS+.

10. In **alpha mode**, the alpha register is displayed in the dot matrix, starting with the first character it is containing, while the numeric section keeps the result of the last numeric operation, e.g.:




Different information may be appended to ***alpha***. See the commands starting with “α” in the index of operations below. E.g. αTIME allows creating texts like

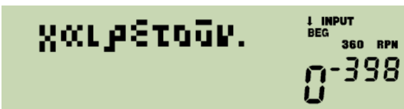
or



depending on time mode setting (12h / 24h). And αDATE will append – depending on date format setting – either 2011-03-14 or 14.03.2011 or 03/14/2011 to ***alpha***.

Please note ***alpha*** may be considerably longer than the display window. And the WP 34S features a rich set of special letters. So you may store a message like

easily but you will see its right end only, i.e.



in this very special case.

**All keyboard input will be interpreted according to the mode set at input time.**

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## FONTS

The WP 34S features a large and a small font. Both are based on Luiz Viera's fonts as distributed in 2004. Some letters were added and some modified for better legibility, since the dot matrix is only 6 pixels high here. The following tables show the characters directly accessible through the keyboard. More are in the alpha catalogs (see below).

| |
|---|
| A B C D E F G H I J K L M N O P Q R S T U V W X Y Z |
| ABCDEFGHIJKLM NOPQRSTUVWXYZ |
| ABCDEFGHIJKLM NOPQRSTUVWXYZ |

| |
|---|
| a b c d e f g h i j k l m n o p q r s t u v w x y z |
| abcdefghijklm nopqrstuvwxyz |
| abcdefghijklm nopqrstuvwxyz |

| |
|---|
| Α Β Γ Δ Ε Ζ Η Θ Ι Κ Λ Μ Ν Ξ Ο Π Ρ Σ Τ Υ Φ Χ Ψ Ω |
| ΑΒΓΔΕΖΗΘΙΚΛΜ ΝΞΟΠΡΣΤΥΦΧΨΩ |
| ΑΒΓΔΕΖΗΘΙΚΛΜ ΝΞΟΠΡΣΤΥΦΧΨΩ |

| |
|---|
| α β γ δ ε ζ η ϑ ι κ λ μ ν ξ ο π ρ σ τ υ φ χ ψ ω |
| αβγδεζηϑικλμ νξοπρστυφχψω |
| αβγδεζηϑικλμ νξοπρστυφχψω |

| | | |
|---|---|---|
| 0 1 2 3 4 5 6 7 8 9 | ( ) + - × / ± . ! | ↔ % √ \ & | ≠ $ € £ ¥ |
| 0123456789 | ()+-×/±.! | ↔%√\&|≠$€£¥ |
| 0123456789 | ()+-×/±.! | ↔%√\&|≠$€£¥ |

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## INDEX OF OPERATIONS

All functions available are found below with their names and keystrokes necessary. Names printed in **bold** face therein belong to commands directly accessible on the keyboard, the others are accessible via catalogs. These names will show up in program listings as well. Sorting in index and catalogs is case insensitive and works in the following order:

␣, 0…9, A…Z, !, α…ω, ( ) + – × / ± , . ? : ; ' " # * @ _ ~
→ ← ↑ ↓ ↔ < ≤ = ≠ ≥ > % $ € £ ¥ √ ∫ ∞ & \ ^ | G [ ] { }

Super- and subscripts are handled like normal characters in sorting.

Generally, functions and keystroke programming will work as on *HP-42S*, bit and integer functions as on *HP-16C*, unless stated otherwise under remarks. Especially, all **tests** will return "Yes" or "No" in the dot matrix if called from the keyboard; if called in a program, they will skip the next program line if the test is false. Please refer to the manuals of the vintage calculators mentioned, e.g. on the DVDs distributed by *www.hpmuseum.org*.

Functions available on the WP 34S for the first time on an RPN calculator are highlighted yellow under remarks, while operations carrying a familiar name but deviating in their functionality here are marked light red.

***Parameters*** will be taken from the lowest stack levels unless being mentioned explicitly in the 2nd column. Then they must follow the command. If ***underlined***, they may also be specified using indirect addressing, as shown in the *tables* above. Some parameters of statistical distributions must be given in registers **J** and **K** if specified.

Each function is listed stating the mode(s) it will work in, abbreviated by their *indicators*. In this column an "&" stands for a Boolean AND, a comma for an OR, and a backslash for "not". So e.g. $2^X$ works in all modes but alpha. All operations will also work in mode PRG unless stated otherwise explicitly.

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| **c…** | CPX … | DECM | Indicates an operation in complex domain (see *above*). CPX may be combined with all functions whose *names are printed in italics here* . |
| ***10^x*** | f 10^x | DECM | |
| 12h | h MODE 12h | \α | Sets 12h time display mode meaning 1:23 becomes 1:23 a.m. and 13:45 becomes 1:45 p.m. |
| 1COMPL | h MODE 1COMPL | \α | Sets 1's complement mode like in *HP-16C*. |
| ***1/x*** | f 1/x | DECM | |
| | B | DECM | Shortcut as long as label B is not defined yet. |
| 24h | h MODE 24h | \α | Sets 24h time display mode meaning 1:23 a.m. becomes 1:23, and 1:45 p.m. becomes 13:45. |
| 2COMPL | h MODE 2COMPL | \α | Sets 2's complement mode like in *HP-16C*. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| ***$2^x$*** | f $2^x$ | \α | |
| ***ABS*** | f \|x\| | \α | $^{C}$ABS returns $r=\sqrt{x^2+y^2}$ in **X** and clears **Y**. |
| ***ACOS*** | g $COS^{-1}$ | DECM | |
| ***ACOSH*** | g $HYP^{-1}$ COS | | |
| **ALL** | h FIX . | \α | Selects the format displaying "all" digits. |
| **AND** | h AND | Integer | Works bitwise as in *HP-16C*. |
| | | DECM | Works like AND in *HP-28S*, i.e. ***x*** and ***y*** are interpreted before executing this operation. 0 is "false", any other real number is "true". |
| ANGLE | h X.FCN ANGLE | DECM | Calculates the angle between positive x-axis and the straight line from the origin to the point (***x, y***) , returns this angle in **X** and clears **Y**. |
| ***ASIN*** | g $SIN^{-1}$ | DECM | |
| ***ASINH*** | g $HYP^{-1}$ SIN | | |
| ASR | h X.FCN ASR ***n*** | Integer | Works like ***n*** (up to 63) consecutive ASRs in *HP-16C*. ASR 0 executes as NOP. |
| ***ATAN*** | g $TAN^{-1}$ | DECM | |
| ***ATANH*** | g $HYP^{-1}$ TAN | | |
| BASE | h MODE BASE ***n*** | \α | Sets the base for integer calculations, with $2 \le n \le 16$. Popular bases are directly accessible on the keyboard. Current integer base setting is indicated in the exponent as explained *above*. Furthermore, BASE0 equals DECM, and BASE1 calls FRACT. |
| **BASE10** | f 10 | | |
| **BASE16** | g 16 | | |
| **BASE2** | f 2 | | |
| **BASE8** | g 8 | | |
| BC? | h TEST BC? ***n*** | Integer | Tests the specified bit in ***x*** . |
| BestF | h STAT BestF | DECM | Selects the best curve fit model, maximizing the correlation like BEST does in *HP-42S*. |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| Binom | h PROB Binom | DECM | Binomial distribution with the number of successes ***g*** in $\mathbf{X}$, the gross error probability ***p*** in $\mathbf{J}$ and the sample size ***n*** in $\mathbf{K}$: pmf [16]: $P_B(g;n;p)=\binom{n}{g}\cdot p^g\cdot(1-p)^{n-g}$. cdf: $F_B(m;n;p)=\sum_{g=0}^{m}P_B(g;n;p)$, with the maximum number of successes ***m*** in $\mathbf{X}$. The pdf equals BINOMDIST(***g; n; p;*** **0**) and the cdf BINOMDIST(***m; n; p;*** **1**) in MS Excel. |
| $\mathrm{Binom}_P$ | h PROB $\mathrm{Binom}_P$ | DECM | |
| $\mathrm{Binom}^{-1}$ | h PROB $\mathrm{Binom}^{-1}$ | DECM | Returns ***m*** for given probabilities $\boldsymbol{F_B}$ in $\mathbf{X}$ and ***p*** in $\mathbf{J}$ with sample size ***n*** in $\mathbf{K}$. |
| BS? | h TEST BS? ***n*** | Integer | Tests the specified bit in $x$ . |
| Cauch | h PROB Cauch | DECM | Cauchy-Lorentz distribution, also known as Lorentz or Breit-Wigner distribution: pdf: $f_{Ca}(x)=\frac{1}{\pi\gamma}\cdot\frac{1}{1+\left(\frac{x-x_0}{\gamma}\right)^2}$ cdf: $F_{Ca}(x)=\frac{1}{2}+\frac{1}{\pi}\arctan\left(\frac{x-x_0}{\gamma}\right)$ with the location $\boldsymbol{x_0}$ specified in $\mathbf{J}$ and the shape $\gamma$ in $\mathbf{K}$. |
| $\mathrm{Cauch}_P$ | h PROB $\mathrm{Cauch}_P$ | DECM | |
| $\mathrm{Cauch}^{-1}$ | h PROB $\mathrm{Cauch}^{-1}$ | DECM | Returns ***x*** for a given probability $\boldsymbol{F_{Ca}}$ in $\mathbf{X}$, with location $\boldsymbol{x_0}$ in $\mathbf{J}$ and shape $\gamma$ in $\mathbf{K}$. |
| CB | h X.FCN CB ***n*** | Integer | Clears the specified bit in $x$ . |
| CEIL | h X.FCN CEIL | DECM | Returns the smallest integer ≥ $x$ . |
| CF | h P.FCN CF ***n*** | \α | Clears the flag specified. |
| CLFLAG | h P.FCN CLFLAG | \α | Clears all user flags. |
| CLREG | h X.FCN CLREG | All | Clears all general purpose registers. |
| **CLSTK** | 0 g FILL<br>h P.FCN CLSTK | \α | Clears all stack registers. |

[16] pmf = probability mass function (German: „Dichtefunktion“),
cdf = cumulative distribution function (German: „Verteilungsfunktion“ / „Wahrscheinlichkeitsverteilung“),
pdf = probability density function (German: „Wahrscheinlichkeitsdichte“).
In the WP 34S, for a cdf named Xyz, the pdf or pmf is named $\mathrm{Xyz}_P$ .

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| ***CLx*** | h CLx | All | |
| | CPX h CLx | DECM | Clears both **X** and **Y**. |
| **CLα** | f CLα | All | Clears the alpha register like CLA in *HP-42S*. |
| **CLΣ** | g CLΣ | DECM | Clears all statistical sums. |
| ***COMB*** | f $C_{y,x}$ | DECM | Returns the number of possible sets of ***y*** items taken ***x*** at a time. No item occurs more than once in a set, and different orders of the same ***x*** items are not counted separately.<br>Formula: $C_{y,x} = \binom{y}{x} = \frac{y!}{x! \cdot (y-x)!}$ |
| *CONJ* | CPX X.FCN CONJ | DECM | Changes the sign of ***y*** . |
| **CORR** | g r | DECM | Returns the correlation coefficient for the current statistical data and curve fitting model. |
| ***COS*** | f COS | DECM | |
| ***COSH*** | f HYP COS | | |
| COV | h STAT COV | DECM | Returns the population covariance for two data sets. It depends on the fit model selected. For LinF, it calculates<br>$COV_{xy} = \frac{1}{n^2}\left(n\sum x_i y_i - \sum x_i \sum y_i\right)$ |
| DATE | h X.FCN DATE | DECM | Recalls the date from the real time clock and displays it in the numeric section in the format selected. See D.MY, M.DY, and Y.MD.<br>The function DATE in *HP-12C* corresponds to DAYS+ in WP 34S (see below). |
| DAY | h X.FCN DAY | DECM | Takes ***x*** as a date in the format selected and returns the name of the day in the dot matrix and a corresponding integer in the numeric display (Monday = 1, Sunday = 7). |
| DAYS+ | h X.FCN DAYS+ | DECM | Works like DATE in *HP-12C*, adding ***x*** days on a date in **Y** in the format selected and displaying the resulting date including the day of week in the same format as DAY does. |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| DBLR | h X.FCN DBLR | Integer | Double precision commands like in *HP-16C*. |
| DBL × | h X.FCN DBL× | | |
| DBL / | h X.FCN DBL/ | | |
| DEC | h P.FCN DEC *r* | \α | Decrements ***r*** by one, equivalent to 1 STO– ***r*** , but without modifying the stack. |
| **DECM** | f H.d | \α | |
| DECOMP | h X.FCN DECOMP | FRC | Decomposes $x$ (after converting it into an improper fraction, if applicable), resulting in a stack [***numerator(x), denominator(x), y, z***] or [***num(x), den(x), y, z, t, a, b, c***] , respectively. Reversible by division. |
| **DEG** | g DEG | DECM | Sets angular mode to degrees. |
| DENANY | h MODE DENANY | \α | Sets default fraction format like in *HP-35S*, allowing maximum precision. Any denominator up to the value set by DENMAX may appear. |
| DENFAC | h MODE DENFAC | \α | Sets "factors of the maximum denominator". With e.g. DENMAX = 60, possible denominators are 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, and 60. |
| DENFIX | h MODE DENFIX | \α | Sets fixed denominator format, i.e. the denominator equaling DENMAX always. |
| DENMAX | h MODE DENMAX | \α | Works like /c in *HP-35S*, but maximum denominator settable is 9999. It will be set to this value if $x < 1$ or $x > 9999$ at execution time. For $x = 1$ the current setting is recalled. |
| DISP | h MODE DISP | DECM | Changes the number of decimals while keeping the display format (FIX, SCI, ENG) as is. |
| *DROP* | h P.FCN DROP | \α | Drops $x$ , changing stack contents to [***y, z, t, t***] or [***y, z, t, a, b, c, d, d***] , respectively. See *above* for ᶜDROP. |
| **DSE** | f DSE *r* | PRG & DECM | Given `cccccc.fffii` in ***r*** , this function decrements ***r*** by `ii`, skipping next program line if then `ccccccc` ≤ `fff` . |
| DSZ | h P.FCN DSZ *r* | PRG | Decrements ***r*** by one, skipping next program line if then $\lvert r\rvert < 1$ . |
| D.MY | h MODE D.MY | \α | Sets the format for date display. |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| D→J | h X.FCN D→J | DECM | Takes $x$ as a date in the format selected and converts it to a Julian day number. |
| D→R | h X.FCN D→R | DECM | Takes $x$ as degrees and converts them to radians. Angular mode is kept. |
| E3OFF | h MODE E3OFF | \α | Toggle the thousands separator (either a point or a comma depending on the radix setting). |
| E3ON | h MODE E3ON | | |
| **ENG** | h ENG ***n*** | \α | Sets engineering display format. |
| **ENGOVR** | h ENG . | \α | Extension of ALL and FIX formats: numbers exceeding the range displayable in these formats will be shown in engineering format. See SCIOVR. |
| ***ENTER↑*** | ENTER↑ | \α | See *above* for CENTER. |
| erf | h STAT erf | DECM | Calculates the error function $$erf(x)=\frac{2}{\sqrt{\pi}}\int_0^x e^{-\tau^2}d\tau$$ |
| EVEN? | h TEST EVEN? | \α | Checks if $x$ is integer and even. |
| ***e*** ***x*** | f $e^x$ | DECM | |
| ExpF | h STAT ExpF | DECM | Selects the exponential curve fit model. |
| Expon | h PROB Expon | DECM | Exponential distribution with the rate $\lambda$ specified in **J** :<br>pdf: $f_{Ex}(x)=\lambda\cdot e^{-\lambda x}$ = EXPONDIST(***x; λ;*** **0**),<br>cdf: $F_{Ex}(x)=1-e^{-\lambda x}$ = EXPONDIST(***x; λ;*** **1**) in MS Excel. |
| $Expon_P$ | h PROB $Expon_P$ | | |
| $Expon^{-1}$ | h PROB $Expon^{-1}$ | DECM | Returns the survival time $t_s$ for a given probability $F_{Ex}$ in **X** and rate $\lambda$ in **J**. |
| *$e^x$ -1* | h X.FCN $e^x$-1 | DECM | Returns more accurate results for the fractional part of $e^x$ with $x \approx 0$ . |
| FB | h X.FCN FB ***n*** | Integer | Inverts (“flips”) the specified bit in $x$ . |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| FC? <br> FC?C <br> FC?F <br> FC?S | h TEST FC? ***n*** etc. | \α | Tests the flag specified. Clears, flips, or sets this flag after testing, if applicable. |
| FF | h P.FCN FF ***n*** | \α | Flips the flag specified. |
| *FIB* | h X.FCN FIB | \α | Calculates the Fibonacci number $F_x$ . |
| ***FILL*** | g FILL | \α | Copies $x$ to all stack levels. See above for CFILL. |
| **FIX** | h FIX ***n*** | \α | Sets fixed point display format. |
| FLOOR | h X.FCN FLOOR | DECM | Returns the largest integer $\leq x$ . |
| ***FP*** | g FP | DECM | Returns the fractional part of $x$ . |
| FP? | h TEST FP? | \α | Tests $x$ for having a nonzero fractional part. |
| FRACT | h P.FCN FRACT | DECM | Sets fraction mode like in HP-35S, but keeps display format as set by PROFRC or IMPFRC. |
| FS? <br> FS?C <br> FS?F <br> FS?S | h TEST FS? ***n*** etc. | \α | Tests the flag specified. Clears, flips, or sets this flag after testing, if applicable. |
| F(x) | h PROB F(x) | DECM | F equals 1 - Q(F) in *HP-21S*. The degrees of freedom are specified in **J** and **K**. |
| $F^{-1}$(p) | h PROB $F^{-1}$(p) | DECM | |
| f'(x) | h P.FCN f'(x) ***label*** | DECM | Return the first or second derivative of the function ***f(x)*** at position $x = x$, respectively, with ***f(x)*** being specified in a routine starting with LBL ***label***. The return stack will have $y$, $z$, and $t$ cleared and the position $x$ in **L**. <br> Either command will attempt to call a user routine labeled 'δx' to provide a fixed step size ***dx***. If that routine is not defined, a step size of 0.1 is employed instead. |
| f"(x) | h P.FCN f"(x) ***label*** | DECM | |
| GCD | h X.FCN GCD | \α | Returns the Greatest Common Divisor of $x$ and $y$ . |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| Geom | h PROB Geom | DECM | Geometric distribution:<br>pdf: $f_{Ge}(m) = p_0(1-p_0)^m$,<br>cdf: $F_{Ge}(m) = 1-(1-p_0)^{m+1}$ is the probability for a first success after ***m*** = ***x*** Bernoulli experiments. The probability $\boldsymbol{p_0}$ for a success in each such experiment must be specified in **J**. |
| Geom$_P$ | h PROB Geom$_P$ | | |
| Geom $^{-1}$ | h PROB Geom $^{-1}$ | DECM | Returns the number of failures ***f*** before the first success for given probabilities $\boldsymbol{F_{Ge}}$ in **X** and $\boldsymbol{p_0}$ in **J**. |
| **GRAD** | g GRAD | DECM | Sets angular mode to gon or grads. |
| **GTO** | h GTO ***label*** | PRG | Inserts an unconditional branch to ***label***. |
| | | \PRG, \α | Positions the program pointer to ***label***. |
| | h GTO . ***nnn*** | \α | … to line ***nnn*** (not programmable). |
| | h GTO . . | \α | … to line 000 (not programmable) and lights the annunciator ***BEG***. |
| H$_n$ | h X.FCN H$_n$ | DECM | Hermite's polynomials for probability:<br>$H_n(x) = (-1)^n \cdot e^{x^2/2} \cdot \frac{d^n}{dx^n}\left(e^{-x^2/2}\right)$ with ***n*** in **Y**,<br>solving the differential equation<br>$f''(x) - 2x \cdot f'(x) + 2n \cdot f(x) = 0$ . |
| H$_{np}$ | h X.FCN H$_{np}$ | DECM | Hermite's polynomials for physics:<br>$H_{np}(x) = (-1)^n \cdot e^{x^2} \cdot \frac{d^n}{dx^n}\left(e^{-x^2}\right)$ with ***n*** in **Y**. |
| **H.MS** | f H.MS | DECM | Assumes **X** containing decimal hours or degrees, and displays them in the format `hhhh°mm'ss.dd"` as shown above. Returns to the previous decimal display with the next keystroke thereafter. |
| **H.MS+** | h P.FCN H.MS+ | DECM | Assumes **X** and **Y** containing times or degrees in the format `hhhh.mmssdd`, and adds or subtracts them, respectively. |
| **H.MS–** | h P.FCN H.MS– | | |



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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| **IMPFRC** | g d/c | \α | Sets fraction mode allowing improper fractions in display (i.e. 5/3 instead of 1 2/3). Converts ***x*** according to the settings by DEN… Absolute decimal equivalents of ***x*** must be >1E-5 and <1E5. Compare PROFRC. |
| | | FRC | Allows displaying improper fractions. Thus converts a proper fraction in **X** into the equivalent improper fraction, if applicable. |
| INC | h P.FCN INC ***r*** | \α | Increments ***r*** by one, equivalent to 1 STO+ ***r*** , but without modifying the stack. |
| INT? | h TEST INT? | \α | Tests ***x*** for being an integer, i.e. having a fractional part equal to zero. Compare FP?. |
| ***IP*** | f IP | DECM | Returns the integer part of ***x*** . |
| **ISG** | g ISG ***r*** | PRG & DECM | Given `cccccc.fffii` in ***r*** , this function increments ***r*** by `ii`, skipping next program line if then `ccccccc` > `fff`. |
| ISZ | h P.FCN ISZ ***r*** | PRG | Increments ***r*** by one, skipping next program line if then $\lvert r \rvert < 1$. |
| I β | h X.FCN Iβ | DECM | Returns the regularized incomplete beta function $\frac{\beta_x(x,y,z)}{\beta(y,z)} = \frac{1}{\beta(y,z)} \cdot \int_0^x t^{y-1}(1-t)^{z-1}dt$ with $\beta_x$ being the incomplete beta function and $\beta$ being Euler's beta (see below). |
| I Γ | h X.FCN IΓ | DECM | Returns the regularized incomplete gamma function $\frac{\gamma(x,y)}{\Gamma(x)}$ with $\gamma(x,y) = \int_0^y t^{x-1}e^{-t}dt$ being the lower incomplete gamma function. For $\Gamma$ see below. |
| J→D | h X.FCN J→D | DECM | Takes ***x*** as a Julian day number and converts it to a date in the format selected. |
| ***LASTx*** | RCL L | \α | See *above* for $^C$LASTx . |
| **LBL** | f LBL ***label*** | PRG | Identifies programs and routines for execution and branching. See opportunities for specifying ***label*** in the table *above*. |
| LBL? | h TEST LBL? ***label*** | All | Tests for the existence of the label specified, anywhere in program memory. See opportunities for specifying ***label*** in the table *above*. |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| LCM | h X.FCN LCM | \α | Returns the Least Common Multiple of $x$ and $y$. |
| LEAP? | h TEST LEAP? | DECM | Takes $x$ as a date in the format selected, extracts the year, and tests for a leap year. |
| LgNrm | h PROB LgNrm | DECM | Lognormal distribution with $\mu = \ln \bar{x}_g$ specified in **J** and $\sigma = \ln \varepsilon$ in **K**. See x̄g and ε below.<br>pdf: $f_{Ln}(x) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\ln x-\mu)^2}{2\sigma^2}}$,<br>cdf: $F_{Ln}(x) = \Phi\left(\frac{\ln x - \mu}{\sigma}\right)$ with $\Phi(z)$ denoting the standard normal cdf. |
| $LgNrm_P$ | h PROB $LgNrm_P$ | | |
| $LgNrm^{-1}$ | h PROB $LgNrm^{-1}$ | DECM | Returns $x$ for a given probability $F_{Ln}$ in **X**, $\mu$ in **J**, and $\sigma$ in **K** (see above). |
| LinF | h STAT LinF | DECM | Selects the linear curve fit model. |
| LJ | h X.FCN LJ | Integer | |
| ***LN*** | g LN | DECM | |
| $L_n$ | h X.FCN $L_n$ | DECM | Laguerre's polynomials (compare $L_n\alpha$ below):<br>$L_n(x) = \frac{e^x}{n!} \cdot \frac{d^n}{dx^n}\left(x^n e^{-x}\right) = L_n^{(0)}(x)$ with $n$ in **Y**, solving the differential equation<br>$x \cdot y'' + (1-x)y' + ny = 0$ . |
| *LN1+x* | h X.FCN LN1+x | DECM | Natural logarithm for values close to zero. Returns $\ln(1+x)$, providing a much higher accuracy in the fractional part of the result. |
| $L_n\alpha$ | h X.FCN $L_n\alpha$ | DECM | Laguerre's generalized polynomials with $n$ in **Y** and **α** in **Z**:<br>$L_n^{(\alpha)}(x) = \frac{x^{-\alpha} e^x}{n!} \cdot \frac{d^n}{dx^n}\left(x^{n+\alpha} e^{-x}\right)$ . |
| *LN β* | h STAT LNβ | DECM | Returns the natural logarithm of Euler's $\beta$. See there. Also contained in the catalog X.FCN. |
| *LN Γ* | h STAT LNΓ | DECM | Returns the natural logarithm of $\Gamma(x)$. See there. Also contained in the catalog X.FCN. |
| ***$LOG_{10}$*** | g LG | DECM | |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| ***LOG$_2$*** | g LB | \α | Calculates the logarithm of $x$ for base 2. |
| LogF | h STAT LogF | DECM | Selects the logarithmic curve fit model. |
| Logis | h PROB Logis | DECM | Logistic distribution with ***μ*** specified in **J** and ***s*** in **K** :<br>pdf: $f_{Lg}(x) = e^{-\frac{x-\mu}{s}} \Big/ s \cdot \left(1+e^{-\frac{x-\mu}{s}}\right)^2$ ,<br>cdf: $F_{Lg}(x) = \left(1+e^{-\frac{x-\mu}{s}}\right)^{-1}$ |
| Logis$_P$ | h PROB Logis$_P$ | | |
| Logis $^{-1}$ | h PROB Logis$^{-1}$ | DECM | Returns $F_{Lg}^{-1}(p) = \mu + s \cdot \ln\left(\frac{p}{1-p}\right)$ for a probability ***p*** given in **X**, ***μ*** in **J**, and ***s*** in **K**. |
| ***LOGx*** | g LOGx | DECM | Calculates the logarithm of $y$ for base $x$ . |
| | CPX g LOGx | DECM | Calculates the complex logarithm of $z + i\,t$ for the complex base $x + i\,y$ . |
| LZOFF | h MODE LZOFF | Integer | Toggles leading zeros like flag 3 does in *HP-16C*. |
| LZON | h MODE LZON | | |
| **L.R.** | h L.R. | DECM | Calculates the parameters ***a1*** and ***a0*** of the fit curve through the data points accumulated, according to the model selected, and pushes them on the stack. For a straight regression line, ***a0*** is the y-intercept and ***a1*** the slope. |
| MASKL | h X.FCN MASKL ***n*** | Integer | Work like MASKL and MASKR on *HP-16C*, but with the mask length following the command instead of taken from **X**. |
| MASKR | h X.FCN MASKR ***n*** | | |
| MAX | h X.FCN MAX | \α | Returns the maximum of $x$ and $y$ . |
| MIN | h X.FCN MIN | \α | Returns the minimum of $x$ and $y$ . |
| MIRROR | h X.FCN MIRROR | Integer | Reflects the bit pattern in $x$<br>(e.g. 000101 becomes 101000 for word size 6). |
| **MOD** | h MOD | \α | MOD of *HP-42S* equals RMD of *HP-16C*. |
| M.DY | h MODE M.DY | \α | Sets the format for date display. |
| NAND | h X.FCN NAND | \α | Works in analogy to AND. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| NaN? | h TEST NaN? | \α | Tests $x$ for "Not a Number". |
| nBITS | h X.FCN nBITS | Integer | Counts bits set in $x$ like #B does on *HP-16C*. |
| NOP | h P.FCN NOP | PRG | |
| NOR | h X.FCN NOR | \α | Works in analogy to AND. |
| Norml | h PROB Norml | DECM | Normal distribution with an arbitrary mean $\mu$ specified in **J** and standard deviation $\sigma$ in **K** : pdf: $f_N(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$ , cdf: $F_N(x) = \Phi\left(\frac{x-\mu}{\sigma}\right)$ with $\Phi$ denoting the standard normal distribution. The pdf equals NORMDIST(***x; μ; σ;*** **0**) and the cdf NORMDIST(***x; μ; σ;*** **1**) in MS Excel. |
| Norml$_P$ | h PROB Norml$_P$ | DECM | |
| Norml $^{-1}$ | h PROB Norml $^{-1}$ | DECM | Returns $x$ for a given probability $F_N$ in **X**, mean $\mu$ in **J**, and standard deviation $\sigma$ in **K**. Equals NORMINV(***x; μ; σ***) in MS Excel. |
| **NOT** | h NOT | \α | Works in analogy to AND. |
| nΣ | h STAT nΣ | DECM | Recalls the number of accumulated data points. Necessary for basic statistics. |
| ODD? | h TEST ODD? | \α | Checks if $x$ is integer and odd. |
| OFF | h P.FCN OFF | PRG | |
| **OR** | h OR | \α | Works in analogy to AND. |
| ***PERM*** | g Py,x | DECM | Returns the number of possible arrangements of $y$ items taken $x$ at a time. No item occurs more than once in an arrangement, and different orders of the same $x$ items are counted separately. Formula: $P_{y,x} = x! \cdot C_{y,x}$ , see COMB. |
| P$_n$ | h X.FCN P$_n$ | DECM | Legendre's polynomials: $P_n(x) = \frac{1}{2^n n!} \cdot \frac{d^n}{dx^n}\left[\left(x^2-1\right)^n\right]$ with $n$ in **Y**, solving the differential equation $\frac{d}{dx}\left[\left(1-x^2\right)\frac{d}{dx}f(x)\right] + n(n+1)f(x) = 0$. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| Poiss | h PROB Poiss | DECM | Poisson distribution with the number of successes ***g*** in $\mathbf{X}$, the gross error probability ***p*** in $\mathbf{J}$ and the sample size ***n*** in $\mathbf{K}$. Alternatively, Poisson's parameter $\lambda = n \cdot p$ may be in $\mathbf{J}$ if ***k*** = 1: <br> pmf: $P_P(g;\lambda) = \frac{\lambda^g}{g!} e^{-\lambda}$, <br> cdf: $F_P(m;\lambda) = \sum_{g=0}^{m} P_P(g;\lambda)$, with the maximum number of successes ***m*** in $\mathbf{X}$. <br> The pdf equals POISSON( ***g; λ;* 0**) and the cdf POISSON( ***g; λ;* 1**) in MS Excel. |
| $\mathrm{Poiss_P}$ | h PROB $\mathrm{Poiss_P}$ | | |
| $\mathrm{Poiss}^{-1}$ | h PROB $\mathrm{Poiss}^{-1}$ | DECM | Returns ***m*** for given probabilities $\boldsymbol{F_P}$ in $\mathbf{X}$ and ***p*** in $\mathbf{J}$ with sample size ***n*** in $\mathbf{K}$. |
| PowerF | h STAT PowerF | DECM | Selects the power curve fit model. |
| PRIME? | h TEST PRIME? | \α | Checks if the absolute value of the integer part of ***x*** is a prime number. Exact for ***x*** < 66049 , Miller-Rabin with 40 iterations otherwise, with the probability ***P*** for erroneously claiming a composite is prime being $P \approx 2^{-80} \approx 10^{-24}$ . |
| **PROFRC** | f a b/c | DECM | Sets fraction mode like in *HP-35S*, allowing only proper fractions or mixed numbers in display. Converts ***x*** according to the settings by DEN… Absolute decimal equivalents of ***x*** must be >1E-5 and <1E5. Compare IMPFRC. |
| | | FRC | Allows displaying only proper fractions. Thus converts an improper fraction in $\mathbf{X}$, e.g. 5/3 into 1 2/3, if applicable. |
| PROMPT | h P.FCN PROMPT | PRG | Displays ***alpha*** and stops program execution (equaling αVIEW followed by STOP actually). If alpha input is requested for a program, use the sequence αON PROMPT αOFF. <br> With a program running, enter the value or text requested and press R/S to continue. |
| **PSE** | h PSE ***nn*** | PRG | Pauses program execution for ***nn*** times 0.1s, with $0 \le nn \le 99$. Refreshes the display. |
| **RAD** | g RAD | DECM | Sets angular mode to radians. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| **RAN#** | f RAN# | DECM | Returns a random number between 0 and 1 like RAN in *HP-42S*. |
| | | Integer | Returns a random bit pattern for the word size set. |
| ***RCL*** | RCL **s** | \α | See the *addressing table above* for $^{C}$RCL. |
| **RCLM** | RCL MODE | \α | Recalls selected mode settings into **X**. See the paragraph about *indicators* above. |
| RCLS | h P.FCN RCLS **s** | \α | Recalls 4 or 8 values from a set of registers starting at address ***s***, and pushes them on the stack. This is the converse command of STOS. |
| ***RCL+*** | RCL + **s** | \α | Recalls the content of address ***s***, executes the specified operation on it and pushes the result on the stack.<br>E.g. RCL–12 recalls ***r12***, subtracts ***x*** from it and displays the result. RCL↑ (↓) recalls the maximum (minimum) of the values in ***s*** and **X**.<br>See the *addressing table above* for $^{C}$RCL. |
| ***RCL–*** | RCL − **s** | | |
| ***RCL×*** | RCL × **s** | | |
| ***RCL/*** | RCL / **s** | | |
| **RCL↑** | RCL ▲ **s** | | |
| **RCL↓** | RCL ▼ **s** | | |
| **RDX,**<br>**RDX.** | h ./, | DECM | Toggle the radix mark. Also available in P.FCN FWIW. |
| RJ | h X.FCN RJ | Integer | Works in analogy to LJ. |
| RL | h X.FCN RL ***n*** | Integer | Works like ***n*** consecutive RLs / RLCs on *HP-16C*. For RL, 1 ≤ ***n*** ≤ 63. For RLC, 1 ≤ ***n*** ≤ 64. RL 0 and RLC 0 execute as NOP. |
| RLC | h X.FCN RLC ***n*** | | |
| ***ROUND*** | g RND | DECM | Rounds ***x*** using the current display format, like RND in *HP-42S*. |
| | | FRC | Rounds ***x*** using the current denominator, like RND in *HP-35S*. |
| ROUNDI | h X.FCN ROUNDI | DECM | Rounds ***x*** to next integer. ½ rounds to 1. |
| RR | h X.FCN RR ***n*** | Integer | Works like ***n*** consecutive RRs / RRCs on *HP-16C*. See RL / RLC for more. |
| RRC | h X.FCN RRC ***n*** | | |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| **RTN** | g RTN | \PRG | Moves the program pointer to step 000. |
| | | PRG | Last command in a routine. Returns control to the calling routine in program execution, i.e. moves the program pointer one step behind the most recent XEQ instruction encountered. If there is none, program execution halts. |
| R-CLR | h P.FCN R-CLR | DECM | Interprets ***x*** in the form `ss.nn`. Clears ***nn*** registers starting with number ***ss***. E.g. for ***x*** = 34.56, R-CLR will clear **R34** through **R89**. |
| R-COPY | h P.FCN R-COPY | DECM | Interprets ***x*** in the form `ss.nndd`. Takes ***nn*** registers starting with number ***ss*** and copies their contents to ***dd***. E.g. for ***x*** = 7.0345678, ***r07, r08, r09*** will be moved into **R45, R46, R47**, respectively. |
| R-SORT | h P.FCN R-SORT | DECM | Interprets ***x*** in the form `ss.nn`. Sorts the contents of ***nn*** registers starting with number ***ss***. Assume ***x*** = 49.026 , ***r49*** = 1.2 , ***r50*** = –3.4 ; then R-SORT returns ***r49*** = –3.4 , ***r50*** = 1.2. |
| R-SWAP | h P.FCN R-SWAP | DECM | Works like R-COPY but swaps the register contents of source and destination. |
| R→D | h X.FCN R→D | DECM | Takes ***x*** as radians and converts them to degrees. Angular mode is kept. |
| ***R↑*** | h R↑ | \α | Rotates the stack contents one level up or down, respectively. See <u>above</u> for complex rotations. |
| ***R↓*** | R↓ | | |
| **s** | g s | DECM | Calculates the sample standard deviations $s_y$ and $s_x$ and pushes them on the stack. |
| SB | h X.FCN SB ***n*** | Integer | Sets the specified bit in ***x***. |
| **SCI** | h SCI ***n*** | \α | Sets scientific display format. |
| **SCIOVR** | h SCI . | \α | Extension of ALL and FIX formats: numbers exceeding the range displayable in these formats will be shown in scientific format (default as in vintage HP calculators). See ENGOVR. |
| SEED | h STAT SEED | DECM | Stores a seed for random number generation. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| SERR | h STAT SERR | DECM | Works like s but pushes the standard errors $s/\sqrt{n}$ on the stack (i.e. the standard deviations of x̄ and y). |
| SERRw | h STAT SERRw | DECM | Works like sw but returns the standard error $s/\sqrt{\sum y_i}$ (i.e. the standard deviation of x̄w). |
| SETDAT | h X.FCN SETDAT | DECM | Sets the date or time, respectively, for the real time clock (don't work with the emulator). |
| SETTIM | h X.FCN SETTIM | | |
| SF | h P.FCN SF ***n*** | \α | Sets the flag specified. |
| *SIGN* | h X.FCN SIGN | \α | Returns 1 for $x > 0$, –1 for $x < 0$, and 0 for $x = 0$ or non-numbers. |
| | CPX X.FCN SIGN | DECM | Returns the unit vector of $x + i\,y$ in **X** and **Y**. |
| SIGNMT | h MODE SIGNMT | \α | Sets sign-and-mantissa mode for integers. |
| ***SIN*** | f SIN | DECM | |
| *SINC* | h X.FCN SINC | DECM | Returns $\frac{\sin x}{x}$. |
| ***SINH*** | f HYP SIN | DECM | |
| SL | h X.FCN SL ***n*** | Integer | Works like ***n*** (up to 63) consecutive SLs on *HP-16C*. SL 0 executes as NOP. |
| **SLV** | f SLV ***label*** | DECM | Solves the equation $f(x) = 0$, with $f(x)$ calculated by the routine specified. Two initial estimates of the root must be supplied in **X** and **Y** when calling SLV. For the rest, the user interface is as in *HP-15C*. |
| SR | h X.FCN SR ***n*** | Integer | Works like ***n*** consecutive SRs on *HP-16C*. SR 0 executes as NOP. |
| SSIZE4 | h MODE SSIZE4 | \α | Set the stack size to 4 or 8 levels, respectively. If stack size grows, the top level contents will be copied into the new levels. If the stack shrinks, previous top levels will be lost. The same will happen if stack size is changed via STOM. |
| SSIZE8 | h MODE SSIZE8 | | |
| SSIZE? | h TEST SSIZE? | \α | Returns the number of stack levels accessible. |
| ***STO*** | STO ***d*** | \α | See the *addressing table above* for $^{C}$STO. |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| **STOM** | [STO] [MODE] | \α | Sets selected modes as encoded in $\boldsymbol{x}$. See the paragraph about *indicators* above. |
| **STOP** | [R/S] | PRG | Stops program execution. |
| STOS | [h] [P.FCN] STOS ***d*** | \α | Stores all stack levels in a set of 4 or 8 registers, starting at destination ***d***. |
| ***STO+*** | [STO] [+] ***d*** | \α | Executes the specified operation on the content of address ***d*** and stores the result into said address. E.g. STO–12 subtracts $\boldsymbol{x}$ from $\boldsymbol{r12}$, and stores the result in **R12** again. STO↑ (↓) takes the maximum (minimum) of the values in ***d*** and **X** and stores it. See the *addressing table above* for ᶜSTO. |
| ***STO–*** | [STO] [–] ***d*** | | |
| ***STO×*** | [STO] [×] ***d*** | | |
| ***STO/*** | [STO] [/] ***d*** | | |
| **STO↑** | [STO] [▲] ***d*** | | |
| **STO↓** | [STO] [▼] ***d*** | | |
| SUM | [h] [STAT] SUM | DECM | Recalls the linear sums $\boldsymbol{\Sigma y}$ and $\boldsymbol{\Sigma x}$. Useful for basic vector algebra. |
| sw | [h] [STAT] sw | DECM | Returns the standard deviation for weighted data $s_w = +\sqrt{\frac{\sum y_i \cdot \sum\left(y_i \cdot x_i^2\right) - \left[\sum\left(y_i \cdot x_i\right)\right]^2}{\left(\sum y_i\right)^2 - \sum y_i^2}}$ |
| sxy | [h] [STAT] sxy | DECM | Returns the sample covariance for two data sets. It depends on the fit model selected. For LinF, it calculates $s_{xy} = \frac{1}{n\cdot(n-1)}\left(n\sum x_i y_i - \sum x_i \sum y_i\right)$ |
| ***TAN*** | [f] [TAN] | DECM | |
| ***TANH*** | [f] [HYP] [TAN] | | |
| **TIME** | [h] [TIME] | DECM, α | Recalls the time from the real time clock at execution and shows it in decimal mode. |
| $T_n$ | [h] [X.FCN] $T_n$ | DECM | Chebychev's (a.k.a. Tschebyschow) polynomials of first kind $T_n(x)$ with ***n*** in **Y**, solving the differential equation $\left(1-x^2\right)y'' - x\cdot y' + n^2 y = 0$. |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| TVM | h X.FCN TVM | DECM | Time Value of Money. xxx<br>I've added a TVM xrom command FWIW. The command is TVM and it evaluates<br>"PMT - I/k . { PV + (PV + FV) / ( (1+I)^N - 1) }"<br>Use the solver to get an answer.<br>where:<br>PMT = Payment<br>PV = Present Value<br>FV = Future Value<br>ip = Interest Rate per period<br>N = Number of periods<br>k = 1 if payment is made at the end of the period;<br>1 + ip if made at the beginning of the period<br><br>Registers:<br>PMT 80<br>PV 81<br>FV 82<br>I 83<br>N 84<br><br>Flags:<br>80 Set for BEG mode, otherwise END.<br>examples of solver routines to use with TVM. e.g. to solve for PMT this routine should be used:<br>LBL 80<br>SOLVE 00<br>NOP<br>RTN<br>LBL 00<br>STO 80<br>TVM<br>RTN<br>The NOP can be replaced with a second RTN if desired. Both are needed because SOLVE acts as a conditional test. |
| t(x) | h PROB t(x) | DECM | t(x) equals 1 – Q(t) in *HP-21S*. The degree of freedom is stored in **J**. |
| $t^{-1}(p)$ | h PROB $t^{-1}(p)$ | | |
| $U_n$ | h X.FCN $U_n$ | DECM | Chebychev's polynomials of second kind $U_n(x)$ with ***n*** in **Y**, solving the differential equation $(1-x^2)y''-3x\cdot y'+n(n+2)y=0$. |
| UNSIGN | h MODE UNSIGN | \α | Sets unsigned mode for integers. |
| **VIEW** | h VIEW <u>**s**</u> | All | Displays the content of address ***s*** until the next key is pressed. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| *W* | h X.FCN W | DECM | W returns Lambert's W for given $x \geq -1/e$, while $W^{-1}$ returns $x$ for given W ( ≥ -1). |
| $W^{-1}$ | h X.FCN $W^{-1}$ | | |
| Weibl | h PROB Weibl | DECM | Weibull distribution with the shape parameter ***b*** and the characteristic lifetime ***T*** :<br>pdf: $f_W(t) = \frac{b}{T}\left(\frac{t}{T}\right)^{b-1} e^{-\left(\frac{t}{T}\right)^b}$ ,<br>cdf: $F_W(t) = 1 - e^{-\left(\frac{t}{T}\right)^b}$ .<br>The pdf equals WEIBULL(***x; b; T;* 0**) and the cdf WEIBULL(***x; b; T;* 1**) in MS Excel. |
| Weibl$_P$ | h PROB Weibl$_P$ | | |
| Weibl $^{-1}$ | h PROB Weibl $^{-1}$ | | Returns the survival time $\boldsymbol{t_s}$ for given probability $\boldsymbol{F_W}$ , shape parameter ***b*** and characteristic life-time ***T***. |
| WSIZE | h MODE WSIZE ***n*** | \α | Works like WSIZE on *HP-16C*, but with the parameter following the command instead of taken from **X**. WSIZE 0 sets the word size to maximum, i.e. 64 bits. |
| WSIZE? | h TEST WSIZE? | \α | Recalls the word size set. |
| $x^2$ | g $x^2$ | \α | |
| **XEQ** | XEQ ***label*** | PRG | Calls the respective subroutine. |
| | | \PRG, \α | Executes the respective program. |
| | B , C , or D<br>(you may need f for accessing these hotkeys in integer bases >10.) | PRG | Calls the respective subroutine, so e.g. XEQ C will be inserted when C is pressed. |
| | | \PRG, \α | Executes the respective program if defined. |
| XNOR | h X.FCN XNOR | \α | Works in analogy to AND. |
| **XOR** | h XOR | \α | Works in analogy to AND. |
| **x̄** | f x̄ | DECM | Calculates the arithmetic means. Pushes $\frac{1}{n}\sum y$ and $\frac{1}{n}\sum x$ on the stack. See also s, SERR, and σ. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| x̄g | h STAT x̄g | DECM | Calculates the geometric means. Pushes $\sqrt[n]{\prod y} = e^{\frac{1}{n}\sum \ln y}$ and $\sqrt[n]{\prod x}$ on the stack. See also ε, εg, and $\varepsilon_P$. |
| x̄w | h STAT x̄w | DECM | Calculates the weighted arithmetic mean $\sum xy \Big/ \sum y$ . See also sw and SERRw. |
| x̂ | h STAT x̂ | DECM | Returns a forecast ***x*** for a given ***y*** (in **X**) following the fit model chosen. See L.R. for more. |
| ***x !*** | h ! | DECM | |
| x → α | g x◄►α | All | Interprets *x* as a code of up to 6 characters. Appends these characters to ***alpha***, similar to XTOA in *HP-42S*. |
| ***x⇔*** | h x⇄ ***r*** | \α | Swaps the contents of **X** and ***r*** . See *above* for complex x⇔ . |
| ***x⇔ y*** | x⇄y | \α | Swaps ***x*** and ***y*** , performing Re⇔Im if a complex operation was executed immediately before. See *above* for ${}^{C}$x⇔y . |
| x < … ? | h TEST x < ? ***a*** | \α | Compare ***x*** with ***a***. The three dots will be replaced in the listing by ***a*** according to the examples given in the *addressing table above*.<br>x ≈ ? will be true if the rounded values of ***x*** and ***a*** are equal (see ROUND).<br>CPX f x = ? ***a*** and<br>CPX g x ≠ ? ***a*** compare the complex number $x + i\,y$ as explained in the *addressing table above*. |
| x ≤ … ? | h TEST x ≤ ? ***a*** | | |
| ***x = … ?*** | f x = ? ***a*** | | |
| x ≈ … ? | h TEST x ≈ ? ***a*** | | |
| ***x ≠ … ?*** | g x ≠ ? ***a*** | | |
| x ≥ … ? | h TEST x ≥ ? ***a*** | | |
| x > … ? | h TEST x > ? ***a*** | | |
| ***$y^x$*** | f $y^x$ | \α | In integer modes ***x*** must be ≥ 0. |
| | C | \(α, -3, -4, -5, h) | Shortcut working as long as label C is not defined yet. |
| ***ŷ*** | f ŷ | DECM | Returns a forecast ***y*** (in **X**) for a given ***x*** following the fit model chosen. See L.R. for more. |
| Y.MD | h MODE Y.MD | \α | Sets the format for date display. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| αDATE | h X.FCN αDATE | \integer | Takes ***x*** as a date and appends it to ***alpha*** in the format set. See DATE. – To append a date stamp to ***alpha***, call DATE αDATE. |
| αDAY | h X.FCN αDAY | \integer | Takes ***x*** as a date, recalls the name of the respective day and appends its first 3 letters to ***alpha***. |
| αIP | h X.FCN αIP | All | Appends the integer part of ***x*** to ***alpha***, similar to AIP in *HP-42S*. |
| αLENG | h X.FCN αLENG | All | Returns the number of characters found in ***alpha***, like ALENG in *HP-42S*. |
| αMONTH | h X.FCN αMONTH | \integer | Works like αDAY, but processing the month. |
| αOFF | h P.FCN αOFF | PRG & α | Work like AOFF and AON in *HP-42S*, turning alpha mode off and on. |
| αON | h P.FCN αON | PRG & \α | |
| **αRCL** | f RCL ***s*** | α | Interprets the content of the source ***s*** as characters and appends them to ***alpha***. |
| | h X.FCN αRCL ***s*** | \α | |
| αRC# | h X.FCN αRC# ***s*** | All | Takes the content of ***s*** as a number, converts it to a string in the format set, and appends this to ***alpha***. If e.g. ***s*** = 1234 and ENG 2 and RDX**.** are set, then ␣1.23E3 will be appended. |
| αRL | h X.FCN αRL ***n*** | All | Rotates ***alpha*** by ***n*** characters like AROT in *HP-42S*, but with ***n*** ≥ *0* and the parameter trailing the command instead of taken from **X**. αRL 0 executes as NOP. |
| αRR | h X.FCN αRR ***n*** | All | Works like αRL but rotates to the right. |
| αSL | h X.FCN αSL ***n*** | All | Shifts the ***n*** leftmost characters out of ***alpha***, like ASHF in *HP-42S*. αSL 0 equals NOP. |
| αSR | h X.FCN αSR ***n*** | All | Works like αSL but takes the ***n*** rightmost characters instead. |
| **αSTO** | f STO ***d*** | α | Stores the first (i.e. leftmost) 6 characters in the alpha register into destination ***d*** . |
| | h X.FCN αSTO ***d*** | \α | |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| αTIME | h X.FCN αTIME | \integer | Takes ***x*** as a time and appends it to ***alpha*** in the format `hh:mm:ss` according to the time mode selected. See TIME. – To append a time stamp to ***alpha***, call TIME αTIME. |
| αVIEW | h X.FCN αVIEW | \α | Displays ***alpha***. In programs, use αVIEW followed by PSE for message output. |
| α → x | f x◀▶α | All | Returns the character code of the leftmost character in ***alpha*** and deletes this character, like ATOX in *HP-42S*. |
| $\beta$ | h STAT β | DECM | Returns Euler's Beta $B(x,y)=\frac{\Gamma(x)\cdot\Gamma(y)}{\Gamma(x+y)}$ with $\mathrm{Re}(x)>0$ , $\mathrm{Re}(y)>0$. Called $\beta$ here for avoiding ambiguities. Also contained in X.FCN. |
| Γ | h STAT Γ | DECM | Also contained in the catalog X.FCN. |
| ΔDAYS | h X.FCN ΔDAYS | DECM | Assumes **X** and **Y** containing dates in the format chosen and calculates the number of days between them. Works like in *HP-12C*. |
| **Δ%** | f Δ% | DECM | Calculates $100\cdot\frac{x-y}{y}$ like %CH in *HP-42S*. |
| ε | h STAT ε | DECM | Calculates the scattering factors (or geometric standard deviations) $\ln(\varepsilon_y)=\sqrt{\frac{\sum\ln^2(y)-2n\cdot\ln(\bar{y}_G)}{n-1}}$ and $\ln(\varepsilon_x)$ and pushes them on the stack. ε works for the geometric mean in analogy to s for the arithmetic mean but multiplicative. |
| $\varepsilon_m$ | h STAT $\varepsilon_m$ | DECM | Works like ε but pushes $\varepsilon_m=\varepsilon^{1/\sqrt{n}}$ on the stack (the scattering factors of the geometric means). |
| $\varepsilon_p$ | h STAT ε | DECM | Works like ε but with a denominator ***n*** instead of ***n – 1***, returning the scattering factors of the populations. |
| ***π*** | h π | DECM | Complex version copies **π** in **X** and clears **Y**. |

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| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| Π | f π ***label*** | DECM | Computes a product with the routine specified by ***label***. Initially, **X** contains the loop control number in the format `cccccc.fffii` and the product is set to 1. Each run through the routine specified computes a factor. At its end, this factor is multiplied with said product; the operation then decrements `ccccccc` by `ii` and runs said routine again if then `ccccccc` > `fff`, else returns the resulting product in **X**. |
| Σ | g Σ ***label*** | DECM | Computes a sum with the routine specified by ***label***. Initially, **X** contains the loop control number in the format `cccccc.fffii` and the sum is set to 0. Each run through the routine specified computes a summand; at its end, this is added to said sum; the operation then decrements `ccccccc` by `ii` and runs said routine again if then `ccccccc` > `fff`, else returns the resulting sum in **X**. |
| σ | h STAT σ | DECM | Works like s but calculates the standard deviations of the populations instead. |
| $\Sigma\ln^2x$ | h STAT $\Sigma\ln^2x$ etc. | DECM | Recall the respective statistical sums. These sums are necessary for curve fitting models beyond pure linear. Calling them by name enhances readability of programs significantly. |
| $\Sigma\ln^2y$ | | | |
| Σlnx | | | |
| Σlnxy | | | |
| Σlny | | | |
| Σxlny | | | |
| Σylnx | | | |
| σw | h STAT σw | DECM | Works like sw but calculates the standard deviation of the population instead. $\sigma_w = +\sqrt{\frac{\sum y_i (x_i - \bar{x}_w)^2}{\sum y_i}}$ |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| $\Sigma x$ | h STAT $\Sigma x$ etc. | DECM | Recall the respective statistical sums. These sums are necessary for basic statistics and linear curve fitting. Calling them by name enhances readability of programs significantly. |
| $\Sigma x^2$ | | | |
| $\Sigma x^2 y$ | | | |
| $\Sigma xy$ | | | |
| $\Sigma y$ | | | |
| $\Sigma y^2$ | | | |
| **Σ+** | Σ+ | DECM | |
| **Σ–** | h Σ– | | |
| φ(x) | h PROB φ(x) | DECM | Standard normal pdf: $\varphi(x)=\frac{1}{\sqrt{2\pi}}e^{-x^2/2}$ . |
| **Φ(x)** | f Φ | DECM | The standard normal cdf Φ(z) equals 1 – Q in *HP-32E* and 1 – Q(z) in *HP-21S* with $z = x$ . |
| **Φ⁻¹(p)** | g Φ⁻¹ | | |
| $\chi^2$ | h PROB $\chi^2$ | DECM | $\chi^2$ equals 1 – Q($\chi^2$) in *HP-21S*. The degree of freedom is given in **J**. |
| $\chi^2$INV | h PROB $\chi^2$INV | | |
| **+** | + | \α | |
| **–** | – | | |
| **×** | × | | |
| **/** | / | | |
| **//** | g // | DECM | Calculates $\left(\frac{1}{x}+\frac{1}{y}\right)^{-1}$ . |
| **+/–** | +/– | \α | |
| **→DEG** | → ( g ) DEG | DECM | Takes *x* as an angle in the angular mode set, converts it to degrees and changes angular mode in parallel. Prefix g may be omitted here. |
| **→GRAD** | → ( g ) GRAD | DECM | Works like →DEG, but converts to grads. |
| **→H** | → f H.d | DECM | Takes *x* as hours or degrees in the format `hhhh.mmssdd` and converts them into a decimal time or angle. |

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| **→H.MS** | → f H.MS | DECM | Takes $x$ as decimal hours or degrees, converts them into `hhhh.mmssdd` and displays the result in the format `hhhh°mm'ss.dd"` as shown above. Returns to `hhhh.mmssdd` with the next keystroke. |
| **→POL** | g R◀▶P | DECM | Assumes $\mathbf{X}$ and $\mathbf{Y}$ containing 2D Cartesian coordinates $(x, y)$ and converts them to the respective polar coordinates $(r, \vartheta)$. |
| **→RAD** | → ( g ) RAD | DECM | Works like →DEG, but converts to radians. |
| **→REC** | f R◀▶P | DECM | Assumes $\mathbf{X}$ and $\mathbf{Y}$ containing 2D polar coordinates $(r, \vartheta)$ and converts them to the respective Cartesian coordinates $(x, y)$. |
| **%** | g % | DECM | Calculates $\frac{x \cdot y}{100}$. |
| %MG | h X.FCN h % MG | DECM | Calculates the margin [17] $100 \cdot \frac{x-y}{x}$ in % for a price $x$ and cost $y$, like %MU-Price in *HP-17B*. |
| %MRR | h X.FCN h % MRR | DECM | Calculates the mean rate of return in % per period, i.e. $100 \cdot \left[ \left( \frac{x}{y} \right)^{1/z} - 1 \right]$ with $x$ = FV = future value after $z$ periods, $y$ = PV = present value. For $z = 1$, Δ% returns the same result easier. |
| %T | h X.FCN h % T | DECM | Calculates $100 \cdot \frac{x}{y}$, i.e. percent of total FWIW. |
| %Σ | h STAT h % Σ<br>h X.FCN h % Σ | DECM | Calculates $100 \cdot \frac{x}{\sum x}$. |
| **%+** | h %+ | DECM | Adds a markup of $x$ % to a price $y$, calculating $y \cdot (1 + 0.01 \cdot x)$ like in %MU-Cost of *HP-17B*. |
| %+MG | h X.FCN h % +MG | DECM | Calculates a sales price $y / (1 - 0.01 \cdot x)$ by adding a margin [17] of $x$ % to the cost $y$, as %MU-Price does in *HP-17B*. |

[17] Margin corresponds to „Handelsspanne“ in German.

| Name | Keys to press | in modes | Remarks |
|---|---|---|---|
| %– | h %– | DECM | Subtracts a discount of $x$ % from the price $y$, calculating $y\cdot(1-0.01\cdot x)$. |
| √‾ | f √x | \α | |
| | D | \(α, -4, -5, h) | Shortcut working as long as label D is not defined yet. |
| ∫ | g ∫ ***label*** | DECM | Integrates the function given in the routine specified. Lower and upper integration limits must be supplied in **Y** and **X**, respectively. Otherwise, the user interface is as in *HP-15C*. |
| ∞? | h TEST ∞? | \α | Tests $x$ for infinity. |

**Alphanumeric input:**

| Letter or digit | Keys to press | in modes | Remarks |
|---|---|---|---|
| ° | . | DECM | Separates degrees or hours from minutes and seconds, so input format is `hhhh.mmssdd`. The user has to take care where an arbitrary real number represents such an angle or time. |
| **0 … 9** | 0 … 9 | \α | Standard numeric input. For integer bases <10, input of illegal digits throws an error message. |
| | | in addressing | Register input. See the addressing tables above for more. |
| | 0, 1, f 2, … , f 9 | α | Appends the respective digit to ***alpha***. |
| **A … F** | A … F (red print) | -1, -2, -3, -4, -5, h | Numeric input for digits >10. See page 6 for more information. |
| **A … Z** | A … Z (red print) | in addressing | Register input. See the addressing tables above for the letters applicable. |
| | | α | Alphabetic input. See page 7 for more. |
| **E** | E (the key) | DECM | Like EEX in the older vintage calculators. |
| **( or )** | f ◄( / g )► | α | Appends a left / right parenthesis to ***alpha***. |

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| Letter or digit | Keys to press | in modes | Remarks |
|---|---|---|---|
| [/] | Second . | DECM | A persistent 2nd . in input switches to fraction mode and will be interpreted as explained below. Please note you cannot enter E after you entered . twice – but you may delete the 2nd dot while editing the input line. |
| | f . | FRC | First . is interpreted as a space, 2nd as a fraction mark. E.g. input of 2 . 3 . 4 results in 2 ¾ in the display. Improper fractions may be entered starting with a . , e.g. . 3 . 2 . |
| [,] | h ./, XEQ | α | Appends a comma to ***alpha***. |
| [.] or [,] | . | DECM | Inserts a radix mark as selected. |

**Non-programmable control, clearing and information commands:**

| Keys to press | in modes | Remarks |
|---|---|---|
| ▲ / ▼ | Status open | Goes to previous / next set of flags. |
| | Catalog open | Goes to previous / next item in this catalog. |
| | α | Scrolls the display window six characters to the left / right in ***alpha*** if possible. If less than six characters are beyond the limits of the display window on the left / right side, the window will be positioned to the beginning / end of string. Useful for longer strings. |
| | Else | Acts like BST / SST in *HP-42S*. |
| ← | Input pending | Deletes the last digit or character put in. |
| | α | Deletes the rightmost character in ***alpha***. |
| | PRG | Deletes current step. |
| | Else | Acts like CLx. |
| f ◄ / g ► | Integer | Shifts the display window to the left / right like in *HP-16C*. Helpful while working with small bases. |
| f ⇧ | α | Toggles upper and lower case. |
| h X.FCN CLALL | \PRG | Clears all registers and programs if confirmed. |
| h CLP | \α | Clears the current program (i.e. the one the program pointer is in) after confirmation. |

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| Keys to press | in modes | Remarks |
|---|---|---|
| ENTER↑ ↓ | Catalog open | Selects the current item like XEQ below. |
| | α | Turns alpha mode off. |
| EXIT ↓ | Catalog open | Leaves the catalog without executing anything. |
| | Input pending | Cancels the execution of pending operations, returning to the calculator status as it was before. |
| | \PRG & program running | Stops this program like R/S below. |
| | PRG | Leaves programming mode like h P/R below. |
| | α | Turns alpha mode off like ENTER↑ above. |
| | Else | Does nothing. |
| g OFF | All | Turns calculator off. |
| ON | Calculator off | Turns calculator on. |
| h P/R | \PRG, \α | Toggle programming mode for keyboard entry. |
| | PRG | |
| h X.FCN RESET | All | Executes CLALL and resets all modes to start-up default, i.e. 24h, 2COMPL, ALL, DEG, DENANY, DENMAX 9999, DECM, LinF, PROFRC, RDX., SCIOVR, SSIZE4, WSIZE 64, Y.MD. |
| R/S | \PRG, \α | Entered from the keyboard: Runs the current program starting with the current step or stops the running program immediately. Compare the programmable command STOP. |
| h SHOW | DECM & \PRG | Shows the full mantissa until the next key is pressed. |
| | PRG | Displays a CRC-32 checksum of program memory contents (8 hex digits), allowing validation of program integrity. |
| h STATUS | \PRG | Shows the status of all user flags, similar to STATUS on *HP-16C*. See above. |
| h X.FCN VERS | \PRG | Shows the firmware version. |
| XEQ | Catalog open | Selects the item currently displayed and exits, executing the respective command. See above. |
| f α | \α | Turns on alpha mode for keyboard entry. When entering alpha constants in programs, please note there is no concatenation character, since added characters are appended to ***alpha*** always. For starting a new string, use CLα first. Alpha constants will be listed like e.g. ‘Test 1’. |

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| Keys to press | in modes | Remarks |
|---|---|---|
| ➡ f 2 | \α | These commands show $x$ in target integer representation until the next key is pressed. Base is kept as set. Prefix g may be omitted here. If used in integer bases 15 and 16, prefix f must precede the key ➡ |
| ➡ f 10 | | |
| ➡ ( g ) 16 | | |
| ➡ ( g ) 8 | | |

**Catalogs (not programmable):**

Calling a catalog will set temporary alpha mode to allow for typing the first 1 or 2 characters of the item wanted. ▲ and ▼ browse the catalog, XEQ selects the item displayed and exits, while EXIT leaves the catalog without executing anything, returning to the mode as set before. See the *table above about addressing cataloged items*, and the *next paragraph* for detailed item lists.

| Keys to press | in modes | Contents |
|---|---|---|
| h CONST | DECM | Constants like in HP35s. See them listed in a *table below*. |
| CPX CONST | DECM | This will clear **Y** in recalling the constant selected since they are all real. |
| h CONV | DECM | Conversions as listed in a *table below*. |
| f CPX | α | "Complex" letters mandatory for many languages. Upper or lower case will be displayed according to setting (see f ↑ above). |
| h MODE | \α | Mode setting functions. |
| h PROB | DECM | Extra probability distributions. |
| h P.FCN | \α | Extra programming functions. |
| f R↓ | α | Subscripts. |
| h R↑ | α | Superscripts. |
| h STAT | DECM | Extra statistical functions. |
| h TEST | \α | All tests except the two on the keyboard. |
| | α | Comparison symbols and brackets. Parentheses are called by f ( and g ) , respectively. |

| Keys to press | in modes | Contents |
|---|---|---|
| h X.FCN | DECM | Extra real functions. |
| | Integer | Extra integer functions. |
| | α | Extra alpha functions. |
| CPX X.FCN | DECM | Extra complex functions. |
| h ./, | α | Punctuation marks and text symbols. |
| f → | α | Arrows and mathematical symbols. |

DRAFT

## DETAILED CATALOG CONTENTS

The characters necessary to access a specific function from an arbitrary position in the respective catalog are printed bold in this table – ▼ has to be pressed once then for each character printed red – if even the last letter of a name is red, more strokes of ▼ may be needed. A single function, e.g. CB, may be contained in more than one catalog.

The alpha catalogs are found two pages below. See also CONST and CONV in separate paragraphs further below.

| MODE |
|---|
| **12**h |
| **1C**OMPL |
| **24**h |
| **2C**OMPL |
| **B**ASE |
| **DEN**ANY |
| **DEN**FAC |
| **DEN**FIX |
| **DENM**AX |
| **DI**SP |
| **D.**MY |
| **E3**OFF |
| **E3**ON |
| **LZ**OFF |
| **LZ**ON |
| **M.**DY |
| **SI**GNMT |
| **SSI**ZE4 |
| **SSI**ZE8 |
| **U**NSIGN |
| **W**SIZE |
| **Y**.MD |

| PROB | |
|---|---|
| **B**inom | **L**ogis |
| **Bi**nom$_P$ | **Lo**gis$_P$ |
| **Bi**nom $^{-1}$ | **Lo**gis $^{-1}$ |
| **C**auch | **N**orml |
| **Ca**uch$_P$ | **No**rml$_P$ |
| **Ca**uch $^{-1}$ | **No**rml $^{-1}$ |
| **E**xpon | **P**oiss |
| **Ex**pon$_P$ | **Po**iss$_P$ |
| **Ex**pon $^{-1}$ | **Po**iss $^{-1}$ |
| **F**(x) | **t**(x) |
| **F** $^{-1}$(p) | **t** $^{-1}$(p) |
| **Ge**om | **W**eibl |
| **Ge**om$_P$ | **We**ibl$_P$ |
| **Ge**om $^{-1}$ | **We**ibl $^{-1}$ |
| **L**gnrm | **φ**(x) |
| **Lg**nrm$_P$ | $\chi^2$ |
| **Lgn**rm $^{-1}$ | $\chi^2$ INV |

| STAT | |
|---|---|
| **B**estF | **ε** |
| **C**OV | **ε$_m$** |
| **e**rf | **ε$_p$** |
| **E**xpF | **σ** |
| **L**inF | **Σln²x** |
| **LN**β | **Σln²y** |
| **LNΓ** | **Σlnx** |
| **L**ogF | **Σlnxy** |
| **n**Σ | **Σlny** |
| **P**owerF | **σw** |
| **SE**ED | **Σx** |
| **SER**R | **Σx²** |
| **SER**Rw | **Σx²y** |
| **SU**M | **Σxln**y |
| **sw** | **Σxy** |
| **s**xy | **Σy** |
| **$\bar{x}$**g | **Σy²** |
| **$\bar{x}$w** | **Σy**lnx |
| **$\hat{x}$** | **%**Σ |
| **β** | |
| **Γ** | |

| TEST |
|---|
| **B**C? |
| **BS**? |
| **E**VEN? |
| **F**C? |
| **FC**?C |
| **FC?**F |
| **FC?S** |
| **FP**? |
| **FS**? |
| **FS?**C |
| **FS?F** |
| **FS?S** |
| **I**NT? |
| **L**BL? |
| **LE**AP? |
| **N**aN? |
| **O**DD? |
| **P**RIME? |
| **S**SIZE? |
| **W**SIZE? |
| **x** < ? |
| **x ≤ ?** |
| **x ≈ ?** |
| **x ≥ ?** |
| **x > ?** |
| **∞**? |

| P.FCN |
|---|
| **C**F |
| **CL**FLAG |
| **CLS**TK |
| **D**EC |
| **DR**OP |
| **DS**Z |
| **F**F |
| **FR**ACT |
| **f** ’(x) |
| **f** ”(x) |
| **H**.MS+ |
| **H.**MS- |
| **I**NC |
| **IS**Z |
| **N**OP |
| **P**ROMPT |
| **R**CLM |
| **RC**LS |
| **RD**X, |
| **RDX.** |
| **R**-CLR |
| **R-C**OPY |
| **R-S**ORT |
| **R-SW**AP |
| **S**F |
| **ST**OM |
| **STO**S |
| **α**OFF |
| **αO**N |

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X.FCN varies with the mode set; it contains in …

| … alpha mode: | … DECM: | | … integer modes: | |
|---|---|---|---|---|
| | ANGLE | RESET | ASR | RJ |
| CLALL | CEIL | ROUNDI | CB | RL |
| CLREG | CLALL | R→D | CLALL | RLC |
| RESET | CLREG | SETDAT | CLFLAG | RR |
| VERS | DATE | SETTIM | CLREG | RRC |
| αDATE | DAY | SIGN | DBLR | SB |
| αDAY | DAYS+ | SINC | DBL* | SEED |
| αIP | DECOMP | VERS | DBL/ | SIGN |
| αLENG | D→J | W | FB | SL |
| αMONTH | D→R | $W^{-1}$ | FIB | SR |
| αRC# | erf | XNOR | GCD | VERS |
| αRL | $e^x$ -1 | αDATE | LCM | XNOR |
| αRR | FIB | αDAY | LJ | αIP |
| αSL | FLOOR | αIP | MASKL | αLENG |
| αSR | GCD | αLENG | MASKR | αRCL |
| αTIME | H.MS+ | αMONTH | MAX | αRC# |
| | H.MS- | αRCL | MIN | αRL |
| | Iβ | αRC# | MIRROR | αRR |
| | IΓ | αRL | NAND | αSL |
| | J→D | αRR | nBITS | αSR |
| | LCM | αSL | NOR | αSTO |
| | LN1+x | αSR | RESET | αVIEW |
| | LNβ | αSTO | | |
| | LNΓ | αTIME | | |
| | MAX | αVIEW | | |
| | MIN | β | %MRR | |
| | NAND | Γ | %T | |
| | NOR | ΔDAYS | %Σ | |
| | | %MG | %+MG | |

| CPX X.FCN |
|---|
| $^{C}$CONJ |
| $^{C}$DROP |
| $^{C}e^x$ -1 |
| $^{C}$FIB |
| $^{C}$LN1+x |
| $^{C}$LNβ |
| $^{C}$LNΓ |
| $^{C}$SIGN |
| $^{C}$SINC |
| $^{C}$W |
| $^{C}W^{-1}$ |
| $^{C}$β |
| $^{C}$Γ |

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| CPX | | | | | |
|---|---|---|---|---|---|
| À | | | à | | |
| Á | | | á | | |
| Â Ã Ā Ă | | | â ã ā ă | | |
| Ä | | | ä (ă) | | |
| Å | | | å | | |
| Ć | | | ć | | |
| Č | | | č | | |
| Ç | | | ç | | |
| È | | | è | | |
| É | | | é | | |
| Ê Ē Ĕ Ě | | | ê ē ĕ ě | | |
| Ë | | | ë (ě) | | |
| | | | ħ | | |
| Ì | | | ì | | |
| Í | | | í | | |
| Î Ĩ Ī Ĭ | | | î ĩ ī ĭ | | |
| Ï | | | ï ( ĭ ) | | |
| Ñ Ň | | | ñ ň | | |
| Ò | | | ò | | |
| Ó | | | ó | | |
| Ô Õ Ō Ŏ | | | ô õ ō ŏ | | |
| Ö | | | ö (ŏ) | | |
| Ø | | | ø | | |
| Ř | | | ř | | |
| Š | | | š | | |
| | | | ß | | |
| Ù | | | ù | | |
| Ú | | | ú | | |
| Û Ũ Ū Ŭ | | | û ũ ū ŭ | | |
| Ü | | | ü (ŭ) | | |
| Ů | | | ů | | |
| Ý | | | ý | | |
| Ÿ | | | ÿ | | |
| Ž | | | ž | | |

Here are the contents of the alpha catalogs making the WP 34S the most versatile global calculator known. Large font is printed in left column or upper row, small font in right or lower. Accented letters show the same width as unaccented ones wherever possible.

| ./, |
|---|
| , ? : ; ' " # * @ _ ~ ` |
| |
| |

| TEST |
|---|
| < ≤ = ≈ ≥ > [ ] { } |
| |
| |

| → |
|---|
| → ← ↑ ↓ ∫ ∞ ^ |
| |
| |

| R↓ (subscripts) |
|---|
| 0 1 2 A B c e k m n p u μ ∞ |
| |
| |

| R↑ (superscripts) |
|---|
| c ° 2 x x̄ x̂ ȳ ŷ -1 |
| |
| |

DRAFT

The letters provided here allow for correct writing the languages of more than $3 \cdot 10^9$ people, i.e. Afrikaans, Català, Cebuano, Česky, Cymraeg, Deutsch, Eesti, English, Español, Euskara, Français, Gaeilge, Galego, Bahasa Indonesia, Italiano, Basa Jawa, Kiswahili, Kreyòl ayisyen, Magyar, Bahasa Melayu, Nederlands, Português, Quechua, Shqip, Slovenčina, Slovenščina, Basa Sunda, Suomeksi, Svenska, Tagalog, Winaray, Zhōngwén (with a little trick explained below), and almost Hrvatski and Srpski (sorry, no đ) as well as Dansk and Norsk (no æ). If you know further living languages covered, please tell us.

Mandarin Chinese (Zhōngwén) features four tones, usually transcribed like e.g. mā, má, mǎ, and mà. So you need different letters for ā and ă here, and for e, i, o, and u as well. With 6 pixels total character height we found no way to display these in both fonts nicely, keeping letters and accents separated for easy reading. For an unambiguous solution, we suggest using a dieresis (else not employed in Hànyǔ pīnyīn) representing the third tone here. Pinyin writers, we ask for your understanding.

## CONSTANTS

This lists the contents of the catalog CONST. Values of physical constants (*incl. their relative standard deviations given in parentheses below*) are from CODATA 2006, copied in August 2010. Green background denotes exact or almost exact values. The more the color turns to red, the less precise the respective constant is known [18].

The characters necessary to get to a specific function in the catalog are printed bold in this index – ▼ has to be pressed once for each character printed red.

For the units, remember Tesla with $1T = 1\frac{Wb}{m^2} = 1\frac{V \cdot s}{m^2}$ , Joule with $1J = 1N \cdot m = 1\frac{kg \cdot m^2}{s^2}$ and on the other hand $1J = 1W \cdot s = 1V \cdot A \cdot s = \frac{1}{e}eV \approx 6.24 \cdot 10^6 TeV$ . Thus $1\frac{J}{T} = 1A \cdot m^2$ .

| | Numeric value | Unit | Remarks |
|---|---|---|---|
| **a** | 365.2425 | $d$ | Gregorian year (per definition) |
| **a**$_0$ | 5.2917720859**E**-11 *(6.8**E**-10)* | $m$ | Bohr radius $= \frac{\alpha}{4\pi \cdot R_\infty}$ |
| **c** | 2.99792458**E**8 | $m/s$ | Vacuum speed of light (per definition) |
| **c**$_1$ | 3.74177118**E**-16 *(5.0**E**-8)* | $m^2 \cdot W$ | First radiation constant $= 2\pi \cdot h \cdot c^2$ |
| **c**$_2$ | 0.014387752 *(1.7**E**-6)* | $m \cdot K$ | Second radiation constant $= hc/k$ |
| **e** | 1.602176487**E**-19 *(2.5**E**-8)* | $C$ | Electron charge $= \frac{2}{K_J R_K} = \Phi_0 G_0$ |
| **eE** | 2.718281828459045… | 1 | Euler's e. Please note the letter $e$ is used for the electron charge elsewhere in this table. |
| **F** | 96485.3399 *(2.5**E**-8)* | $\frac{C}{mol}$ | Faraday's constant $= e\, N_A$ |
| **g** | 9.80665 | $m/s^2$ | Standard earth acceleration (per definition) |
| **G** | 6.67428**E**-11 *(1.0**E**-4)* | $\frac{m^3}{kg \cdot s^2}$ | Newton's gravitation constant |
| **G**$_0$ | 7.7480917004**E**-5 *(6.8**E**-10)* | $1/\Omega$ | Conductance quantum $= 2e^2/h = 2/R_K$ with the von Klitzing constant $R_K$ = 25812.807557 Ω |

[18] The bracketed values printed here for your kind attention allow you to compute the precision of results you may obtain using these constants. The procedure to be employed is called error propagation. It is often ignored, though essential for trustworthy results – not only in science. Please turn to respective texts before you believe in 4 decimals of a calculation result based on yardstick measurements.

| | Numeric value | Unit | Remarks |
|---|---|---|---|
| **$g_e$** | 2.0023193043622 *(7.4**E**-13)* | 1 | Landé's g-factor |
| **h** | 6.62606896**E**-34 *(5.0**E**-8)* | *J s* | Planck constant |
| **$\hbar$** | 1.054571628**E**-34 *(5.0**E**-8)* | | $= h/2\pi$ |
| **k** | 1.3806504**E**-23 *(1.7**E**-6)* | $J/K$ | Boltzmann constant $= R/N_A$ |
| **$m_e$** | 9.10938215**E**-31 *(5.0**E**-8)* | *kg* | Electron mass |
| **$m_n$** | 1.674927211**E**-27 *(5.0**E**-8)* | | Neutron mass |
| **$m_p$** | 1.672621637**E**-27 *(5.0**E**-8)* | | Proton mass |
| **$m_u$** | 1.660538782**E**-27 *(5.0**E**-8)* | | Atomic unit mass $= 10^{-3}\,kg / N_A$ |
| **$m_\mu$** | 1.88353103**E**-28 *(5.6**E**-8)* | | Muon mass |
| **$N_A$** | 6.02214179**E**23 *(5.0**E**-8)* | $1/mol$ | Avogadro's number |
| **NaN** | | | "not a number" |
| **$p_0$** | 101325 | *Pa* | standard atmospheric pressure (per definition) |
| **R** | 8.314472 *(1.7**E**-6)* | $\frac{J}{mol \cdot K}$ | Molar gas constant |
| **$r_e$** | 2.8179402894**E**-15 *(2.1**E**-9)* | *m* | Classical electron radius $= \alpha^2 \cdot a_0$ |
| **$R_\infty$** | 1.0973731568527**E**7 *(6.6**E**-12)* | $1/m$ | Rydberg constant $= \alpha^2 m_e c / 2h$ |
| **$T_0$** | 273.15 | *K* | = 0°C, standard temperature (per definition) |
| **$t_p$** | 5.39124**E**-44 *(5.0**E**-5)* | *s* | Planck time $= \sqrt{\hbar G / c^5}$ |
| **$V_m$** | 0.022413996 *(1.7**E**-6)* | $m^3/mol$ | Molar volume of an ideal gas at standard conditions $= RT_0 / p_0$ |
| **$Z_0$** | 376.730313461… | *Ω* | Characteristic impedance of vacuum $= \sqrt{\frac{\mu_0}{\varepsilon_0}} = \mu_0 c$ |
| **α** | 7.2973525376**E**-3 *(6.8**E**-10)* | 1 | Fine-structure constant $= \frac{e^2}{4\pi\varepsilon_0 \hbar c} \approx \frac{1}{137}$ |
| γEM | 0.57721566490153286… | 1 | Euler-Mascheroni constant |

| | Numeric value | Unit | Remarks |
|---|---|---|---|
| $\gamma_p$ | 2.675222099**E**8 *(2.6**E**-8)* | $\frac{1}{s \cdot T}$ | Proton gyromagnetic ratio $= {}^{2\mu_P}\!/_{\hbar}$ |
| $\varepsilon_0$ | 8.854187817…**E**-12 | $\frac{A \cdot s}{V \cdot m}$ or ${}^{F}\!/_{m}$ | Electric constant, vacuum permittivity $= \frac{1}{\mu_0 c^2}$ |
| $\lambda_c$ | 2.4263102175**E**-12 *(1.4**E**-9)* | | Compton wavelength of the electron $= {}^{h}\!/_{m_e c}$ |
| $\lambda_{cn}$ | 1.3195908951**E**-15 *(1.5**E**-9)* | *m* | Compton wavelength of the neutron $= {}^{h}\!/_{m_n c}$ |
| $\lambda_{cp}$ | 1.3214098446**E**-15 *(1.9**E**-9)* | | Compton wavelength of the proton $= {}^{h}\!/_{m_p c}$ |
| $\mu_0$ | 1.2566370614…**E**-6 | $\frac{V \cdot s}{A \cdot m}$ | Magnetic constant, also known as vacuum permeability $= 4\pi \cdot 10^{-7} \frac{V \cdot s}{A \cdot m}$ (per definition) |
| $\mu_B$ | 9.27400915**E**-24 *(2.5**E**-8)* | | Bohr's magneton $= {}^{e\hbar}\!/_{2m_e}$ |
| $\mu_e$ | -9.28476377**E**-24 *(2.5**E**-8)* | | Electron magnetic moment |
| $\mu_n$ | -9.6623641**E**-27 *(2.4**E**-7)* | ${}^{J}\!/_{T}$ or $A \cdot m^2$ | Neutron magnetic moment |
| $\mu_p$ | 1.410606662**E**-26 *(2.6**E**-8)* | | Proton magnetic moment |
| $\mu_u$ | 5.05078324**E**-27 *(2.5**E**-8)* | | Nuclear magneton $= {}^{e\hbar}\!/_{2m_p}$ |
| $\mu_\mu$ | -4.49044786**E**-26 *(3.6**E**-8)* | | Muon magnetic moment |
| $\pi$ | 3.141592653589793… | 1 | |
| $\sigma_B$ | 5.6704**E**-8 *(7.0**E**-6)* | $\frac{W}{m^2 K^4}$ | Stefan Boltzmann constant $= \frac{2\pi^5 k^4}{15 h^3 c^2}$ |
| $\Phi$ | 1.61803398874989485… | 1 | Golden ratio $= \frac{1+\sqrt{5}}{2}$ |
| $\Phi_0$ | 2.067833667**E**-15 *(2.5**E**-8)* | *V s* | Magnetic flux quantum $= {}^{h}\!/_{2e} = {}^{1}\!/_{K_J}$ with the Josephson constant $K_J = 4.83597891 \cdot 10^{14}\, {}^{Hz}\!/_{V}$ |
| $\infty$ | | 1 | Infinity (may the Lord of Mathematics forgive us calling this a constant) |

## UNIT CONVERSIONS

These are the contents of the catalog CONV [19]. The characters necessary to access a specific conversion there are printed bold in this index – ▼ has to be pressed once for each character printed red. The constant $\mathbf{T_o}$ may be useful for conversions, too; it is found in the *catalog CONST*. The conversion factors or divisors listed in this table will not be seen when executing a conversion.

| Conversion | | Remarks | Class |
|---|---|---|---|
| **°C**→°F | * 1.8 + 32 | Exactly | Temperature |
| **°F**→°C | - 32 ) / 1.8 | Exactly | Temperature |
| **acres**→ha | * 0.4046873 | 1 ha = $10^4$ m² | Area |
| **ar.**→dB | 10 * lg(R) | Amplitude ratio. Exactly | Ratio |
| **atm**→Pa | * 1.01325**E**5 | Exactly | Pressure |
| **AU**→km | * 1.495979**E**8 | Astronomic units | Length |
| **bhp**→W | * 745.6999 | British horse power | Power |
| **Btu**→J | * 1055.056 | | Energy |
| **cal**→J | * 4.1868 | Exactly | Energy |
| **cft**→*l* | * 28.31685 | Cubic feet | Volume |
| **cm**→inches | / 2.54 | Exactly | Length |
| **dB**→ar. | $10^{R_{dB}/20}$ | Amplitude ratio. Exactly | Ratio |
| **dB**→pr. | $10^{R_{dB}/10}$ | Power ratio. Exactly | Ratio |
| **fathom**→m | * 1.8288 | | Length |
| **feet**→m | * 0.3048 | Exactly | Length |
| **flozUK**→*ml* | * 28.41306 | 1 *ml* = 1 cm³ | Volume |
| **flo**zUS→*ml* | * 29.57353 | | Volume |
| **galUK**→ *l* | * 4.54609 | | Volume |
| **ga**lUS→ *l* | * 3.785418 | | Volume |
| **g**→oz | / 28.34952 | | Mass |
| **g**→**tr**.oz | / 31.10348 | | Mass |
| **ha**→acres | / 0.4046873 | | Area |

[19] For most readers, many of the units appearing here may look obsolete at least. They die hard, however, in some corners of this world. For symmetry reasons, we may also add some traditional Indian and Chinese units. Anyway, this catalog provides the means to convert local to common units.

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| Conversion | | Remarks | Class |
|---|---|---|---|
| **HP**$_e$→W | * 746 | Exactly | Power |
| **i**nches→cm | * 2.54 | Exactly | Length |
| **in**Hg→Pa | * 3386.389 | | Pressure |
| **J**→Btu | / 1055.056 | | Energy |
| **J**→cal | / 4.1868 | Exactly | Energy |
| **J**→**k**Wh | / 3.6**E**6 | Exactly, since 1 h = 3600 s | Energy |
| **k**g→lbm | / 0.4535924 | | Mass |
| **km**→AU | / 1.495979**E**8 | Astronomic units | Length |
| **km**→*l.y.* | / 9.460730**E**12 | Light years | Length |
| **km**→**mi** | / 1.609344 | Exactly | Length |
| **km**→**nm**i | / 1.852 | Nautical miles, exactly | Length |
| **km**→**pc** | / 3.085678**E**16 | Parsec | Length |
| **kW**h→J | * 3.6E6 | Exactly | Energy |
| **l**bf→N | * 4.448222 | | Force |
| **lb**m→kg | * 0.4535924 | | Mass |
| ***l.y.***→km | * 9.460730**E**12 | Light years | Length |
| ***l*** →cft | / 28.31685 | Cubic feet | Volume |
| ***l*** →**g**alUK | / 4.54609 | | Volume |
| ***l*** →**ga**lUS | / 3.785418 | | Volume |
| **m**bar→Pa | * 100 | Exactly | Pressure |
| **mi**→km | * 1.609344 | Exactly | Length |
| **m*l***→flozUK | / 28.41306 | | Volume |
| **m*l***→flozUS | / 29.57353 | | Volume |
| **mm**Hg→Pa | * 133.3224 | 1 torr = 1 mm Hg | Pressure |
| **m**→fathom | / 1.8288 | | Length |
| **m**→**f**eet | / 0.3048 | Exactly | Length |
| **m**→**y**ards | / 0.9144 | Exactly | Length |
| **n**mi→km | * 1.852 | Nautical miles, exactly | Length |
| **N**→lbf | / 4.448222 | | Force |

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| Conversion | | Remarks | Class |
|---|---|---|---|
| **oz**→g | * 28.34952 | | Mass |
| **Pa**→atm | / 1.01325**E**5 | Exactly | Pressure |
| **Pa**→inHg | / 3386.389 | | Pressure |
| **Pa→**mbar | / 100 | Exactly | Pressure |
| **Pa→m**mHg | / 133.3224 | | Pressure |
| **Pa→psi** | / 6894.757 | | Pressure |
| **Pa→torr** | / 133.3224 | | Pressure |
| **pc**→km | * 3.085678**E**16 | Parsec | Length |
| **pr.**→dB | 10 * lg(R) | Power ratio. Exactly | Ratio |
| **psi**→Pa | * 6894.757 | | Pressure |
| **PS(**hp)→W | * 735.4988 | | Power |
| **s**.tons→t | * 0.9071847 | 1 t = $10^3$ kg | Mass |
| **tons**→t | * 1.016047 | | Mass |
| **to**rr→Pa | * 133.3224 | 1 torr = 1 mm Hg | Pressure |
| **tr**.oz→g | * 31.10348 | | Mass |
| **t**→s.tons | / 0.9071847 | | Mass |
| **t**→**tons** | / 1.016047 | | Mass |
| **W**→bhp | / 745.6999 | | Power |
| **W→**$HP_e$ | / 746 | Exactly | Power |
| **W→P**S(hp) | * 735.4988 | | Power |
| **y**ards→m | * 0.9144 | Exactly | Length |

In cases of emergency of a particular type, remember that Becquerel equals Hertz, Gray is the unit for deposited or absorbed energy ( $1Gy = 1J/kg$ ), and Sievert is Gray times a radiation dependant dose conversion factor for the damage caused in human bodies. In this area also some outdated units may be found in older literature: Pour les amis de Mme. Curie, $1Ci = 3.7 \cdot 10^{10} Bq = 3.7 \cdot 10^{10} decays/s$. And for those admiring the very first Nobel laureate in physics, Mr. Röntgen, for finding the x-rays (ruining his hands in these experiments), $1R = 2.58 \cdot 10^{-4} \, {}^{As}\!/\!_{kg}$ .



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## MESSAGES

There are some commands generating messages also in the dot matrix section of the display. Four of them, DAY, DAYS+, STATUS, and VERS, were introduced above in the paragraph about display already. Others are PROMPT, αVIEW and many more alpha commands, and the test commands as mentioned above.

Two constants will return a special display when called: **NaN** and ∞ will show you `not numEric` or `InFinitY`, respectively.

Furthermore, there are a number of error messages. Depending on error conditions, the following messages will be displayed in the mode(s) listed:

| Message | Error Code | Mode(s) | Explanation and Examples |
|---|---|---|---|
| `bad date Error` | 2 | DECM | Invalid date format or incorrect date in input, e.g. month >12, day >31 etc. |
| `bad digit Error` | 9 | Integer | Invalid digit in integer input, e.g. 2 in binary, 9 in octal, or +/- in unsigned mode. |
| `bad mode Error` | 13 | All | Caused by calling an operation in a mode where it is not defined, e.g. SIN in hexadecimal. |
| `domain Error` | 1 | \α | An argument exceeds the domain of the mathematical function called. May be caused by roots or logs of negative numbers (if not preceded by **CPX**), by 0 / 0, LN(0), $\Gamma(0)$, TAN(90°) and equivalents, ATANH(x) for $\lvert \mathrm{Re}(x) \rvert \geq 1$, ACOSH(x) for $\mathrm{Re}(x) < 1$, etc. |
| `invalid PArAMEtEr` | 16 | \α | Similar to error 1 but a parameter specified in **J** or **K** is out of supported range for the function called. May appear e.g. if Ln(x) is called with $j < 0$. |
| `no such LAbEL` | 6 | All | Attempt to address an undefined label. |

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| Message | Error Code | Mode(s) | Explanation and Examples |
|---|---|---|---|
| out of range<br>Error | 8 | All | • A number exceeds the valid range. Caused e.g. by specifying decimals >11, word size >64, negative flag numbers, integers ≥$2^{64}$, hours or degrees >9000, invalid times, denominators ≥9999 etc.<br>• A register address exceeds the valid range. May also happen in indirect addressing.<br>• An R-operation (e.g. R-COPY) attempts exceeding valid register numbers (0 .. 99). |
| SLV ∫ Σ Π<br>nEStEd | 7 | PRG | Nested use of solve, integrate, sum or product is not allowed. |
| stack<br>CLASH | 12 | All | STOS or RCLS attempt using registers that would overlap the stack, e.g. SSIZE = 8 and STOS 94. |
| too few<br>dAtA PointS | 15 | DECM | A statistical calculation was started based on too few data points, e.g. regression or standard deviation for < 2 points. |
| too long<br>Error | 10 | All | Keyboard input is too long for the buffer (should never happen, but who knows). |
| undefined<br>OP-COdE | 3 | All | An instruction with an undefined op-code occurred (should never happen, but who knows). |
| word size<br>too SMALL | 14 | Integer, \PRG | Stack or register content is too big for the word size set. |
| +∞<br>Error | 4 | \α, \PRG | • Division of a number > 0 (or < 0) by zero.<br>• Divergent sum or product or integral.<br>• Positive (or negative) overflow in DECM (see *above*). |
| −∞<br>Error | 5 | | |
| ≥8 levels<br>nEStEd | 11 | PRG | Subroutine nesting exceeds 8 levels. |

Any key pressed will erase the error message displayed and execute with the stack contents present. Thus, the easiest return to the display shown before the error occurred is pressing a prefix twice.

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# APPENDIX A: INTERNAL SUPPORT COMMANDS

Some commands are used in internal routines exclusively and are not accessible from the keyboard. They are listed here for sake of a complete documentation:

<table>
<tr><th>Name</th><th>Purpose and remarks</th></tr>
<tr><td>BACK <u>n</u></td><td>Jumps n program steps backwards (1 ≤ n ≤ 99). So e.g. BACK 01 goes to the previous step. Reaching step 000 stops program execution.</td></tr>
<tr><td>ERR <u>n</u></td><td>Raises the error specified. See <u>above</u> for the respective error codes.</td></tr>
<tr><td>iC <u>n</u></td><td>Internal constants, selected by the number specified:
<table>
<tr><td>0</td><td>0</td><td></td></tr>
<tr><td>1</td><td>1</td><td></td></tr>
<tr><td>2</td><td>5.01402</td><td>Kronrod only weight loop initializer (constants 5 - 14 below)</td></tr>
<tr><td>3</td><td>15.02903</td><td>Gauss-Kronrod weight loop initializer (constants 15 - 29 below)</td></tr>
<tr><td></td><td></td><td>Midpoint location is 0.5.</td></tr>
<tr><td>4</td><td>0.149445554002916905664936468389821</td><td>Kronrod weight for midpoint k10</td></tr>
<tr><td>5</td><td>0.995657163025808080735527280689003</td><td>Kronrod location of k0 and k20</td></tr>
<tr><td>6</td><td>0.011694638867371874278064396062192</td><td>Kronrod weight for k0 and k20</td></tr>
<tr><td>7</td><td>0.930157491355708226001207180059508</td><td>Kronrod location of k2 and k18</td></tr>
<tr><td>8</td><td>0.054755896574351996031381300244580</td><td>Kronrod weight for k2 and k18</td></tr>
<tr><td>9</td><td>0.780817726586416897063717578345042</td><td>Kronrod location of k4 and k16</td></tr>
<tr><td>10</td><td>0.093125454583697605535065465083366</td><td>Kronrod weight for k4 and k16</td></tr>
<tr><td>11</td><td>0.562757134668604683339000099272694</td><td>Kronrod location of k6 and k14</td></tr>
<tr><td>12</td><td>0.123491976262065851077958109831074</td><td>Kronrod weight for k6 and k14</td></tr>
<tr><td>13</td><td>0.294392862701460198131126603103866</td><td>Kronrod location of k8 and k12</td></tr>
<tr><td>14</td><td>0.142775938577060080797094273138717</td><td>Kronrod weight for k8 and k12</td></tr>
<tr><td>15</td><td>0.973906528517171720077964012084452</td><td>Location of g0, g9, k1 and k19</td></tr>
<tr><td>16</td><td>0.066671344308688137593568809893332</td><td>Gauss weight for g0 and g9</td></tr>
<tr><td>17</td><td>0.032558162307964727478818972459390</td><td>Kronrod weight for k1 and k19</td></tr>
<tr><td>18</td><td>0.865063366688984510732096688423493</td><td>Location of g1, g8, k3 and k17</td></tr>
<tr><td>19</td><td>0.149451349150580593145776339657697</td><td>Gauss weight for g1 and g8</td></tr>
<tr><td>20</td><td>0.075039674810919952767043140916190</td><td>Kronrod weight for k3 and k17</td></tr>
<tr><td>21</td><td>0.679409568299024406234327365114874</td><td>Location of g2, g7, k5 and k15</td></tr>
<tr><td>22</td><td>0.219086362515982043995534934228163</td><td>Gauss weight for g2 and g7</td></tr>
<tr><td>23</td><td>0.109387158802297641899210590325805</td><td>Kronrod weight for k5 and k15</td></tr>
<tr><td>24</td><td>0.433395394129247190799265943165784</td><td>Location of g3, g6, k7 and k13</td></tr>
<tr><td>25</td><td>0.269266719309996355091226921569469</td><td>Gauss weight for g3 and g6</td></tr>
<tr><td>26</td><td>0.134709217311473325928054001771707</td><td>Kronrod weight for k7 and k13</td></tr>
<tr><td>27</td><td>0.148874338981631210884826001129720</td><td>Location of g4, g5, k9 and k11</td></tr>
<tr><td>28</td><td>0.295524224714752870173892994651338</td><td>Gauss weight for g4 and g5</td></tr>
<tr><td>29</td><td>0.147739104901338491374841515972068</td><td>Kronrod weight for k9 and k11</td></tr>
</table>
Constants 2 .. 29 are for the 10 / 21 point Gauss-Kronrod quadrature used by the internal integration command. Locations are in the range (0, 1) which is scaled to match the interval of integration. The quadrature sums the weight times the function value at each location to estimate the integral. In Gauss-Kronrod schemes the Gauss points are common to both quadratures although the weights are different. This means two estimates of the integral can be performed without increasing the number of function evaluations which in turn allows an estimate of the error to be made. The cost for this is a reduction in the degree of polynomial function that is always integrated exactly.</td></tr>
</table>

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| Name | Purpose and remarks |
|---|---|
| RTN+1 | Returns control to the calling routine like RTN does, but moves the program pointer to the <u>second</u> line following the most recent XEQ instruction encountered. If there is no matching XEQ, program execution halts. |
| SKIP ***<u>n</u>*** | Skips ***n*** program steps forwards (1 ≤ ***n*** ≤ 99). So e.g. SKIP 02 skips over the next two steps, going e.g. from step 123 to step 126. If the skip would land beyond the end of <u>occupied</u> program memory, the same will happen as if a RTN had been encountered. |
| | The two solver commands described below may use some hidden registers and flags. The start points of the respective register and flag blocks are passed as one argument ***n***.<br><br>Registers:<br>***n***+0 .. ***n***+1: first two estimates ***a*** and ***b*** for the root<br>***n***+2: third estimate ***c***<br>***n***+3: function value at first estimate **f(*a*)**<br>***n***+4: function value at second estimate **f(*b*)**<br><br>Flags:<br>***n***+0 **..** ***n***+7: an eight bit iteration counter<br>***n***+8: "bracket flag" – true if we've got an interval with ***f(a)*** * ***f(b)*** < *0*<br>***n***+9: true if all function evaluations have been constant so far |
| SLVI ***<u>n</u>*** | Initializes the solver. SLVI clears the iteration counter, takes ***a*** and ***b*** and calculates **f(*a*)** and **f(*b*)**, sets the last two flags accordingly, and produces a guess ***c***. There is no stack interaction. |
| SLVS ***<u>n</u>*** | Solver step. Updates the internal solver state based on the last function evaluation. In particular, SLVS takes ***a***, ***b***, ***c***, **f(*a*)**, and **f(*b*)** from the register block plus **f(*c*)** from **X** and updates the register values so that ***c*** and **f(*c*)** replace one of ***a*** and **f(*a*)** or ***b*** and **f(*b*).** It also produces a new guess ***c*** and returns zero in **X** if the solving should continue and non-zero if not. Otherwise, the stack isn't altered. |
| | The built in solver loop looks like this in principle, assuming ***n*** *= 0* :<br>`    SLVI      ; calculate f(a) and f(b) and initialize the registers and flags`<br>`  LBL 00`<br>`    RCL 02    ; recall c`<br>`    XEQUSR    ; call the user's subroutine calculating f(c)`<br>`    x≈ 0?     ; test if the solution has converged`<br>`    GTO 01    ; converged, so exit`<br>`    SLVS      ; update estimates`<br>`    x= 0?     ; should we continue?`<br>`    GTO 00    ; loop back again`<br>`  LBL 01`<br>`    RCL 02    ; best guess so far`<br>`    RTN`<br><br>The actual solver is fairly complex. A combination of quadratic interpolation and a guarded secant method is used. |
| SPEC? | Tests if $x$ is special (i.e. NaN or infinite). |
| XEQUSR | Calls a user subroutine (used by SLV, ∫, Π and Σ). The subroutine is defined by the argument to the initial command (either numeric of alpha label). |

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## APPENDIX B: CANDIDATES FOR FURTHER FUNCTIONS

If space allows, the following functions may be implemented easily since they are coded already. None of these are counting the catalog and function table overheads. Two bytes for a catalog entry (one for each catalog it is in) and 12-20 bytes for a function table entry (but only one of these), i.e. not terribly significant. These are all moderately useful functions.

| Function name and remarks | Size | Domain |
|---|---|---|
| AGM = limit of arithmetic geometric mean. | 528 B | $\mathbb{R}$ |
| Bessel functions of first and second kinds:<br>**$J_n$** & $I_n$: real and complex (argument and order);<br>$Y_n$ & $K_n$: real and complex (argument and order).<br>Remember: $J_n(x) = \sum_{r=0}^{\infty} \frac{(-1)^r \cdot \left(x/2\right)^{2r+n}}{r! \cdot \Gamma(n+r+1)}$ | 4470 B | $\mathbb{R}$, $\mathbb{C}$ |
| Digamma function ($\psi$, needed for Bessel functions of second kind of integer order) | 1384 B | $\mathbb{R}$, $\mathbb{C}$ |
| Fused multiply and add<br>The real version can be replaced by complex multiply.<br>x+y*z can be done via (y, x) * (z, -1) at a pinch. | 96 B | $\mathbb{Z}$, $\mathbb{R}$ |
| Jacobi elliptic functions $S_n$, $C_n$ & $D_n$ | 1780 B | $\mathbb{R}$, $\mathbb{C}$ |
| Riemann's Zeta function $\zeta(x) = \sum_{n=1}^{\infty} \frac{1}{n^x}$ with $\mathrm{Re}(x) > 1$ . | 2012 B | $\mathbb{R}$, $\mathbb{C}$ |
| x!! | 288 B | $\mathbb{R}$, $\mathbb{C}$ |

PRIME? also includes overflow resistant code for ***(a * b)*** *mod* ***c*** and ***(a ^ b)*** *mod* ***c*** which could also be exposed if required.

| | Date | Release notes |
|---|---|---|
| 1 | 9.12.08 | Start |
| 1.1 | 15.12.08 | Added the table of indicators; added NAND, NOR, XNOR, RCLWS, STOWS, //, N, SERR, SIGMA, < and >; deleted HR, INPUT, 2 flag commands, and 2 conversions; extended explanations for addressing and COMPLEX & …; put XOR on the keyboard; corrected errors. |
| 1.2 | 4.1.09 | Added ASRN, CBC?, CBS?, CCB, SCB, FLOAT, MIRROR, SLN, SRN, >BIN, >DEC, >HEX, >OCT, BETA, D>R, DATE, DDAYS, D.MY, M.DY, Y.MD, CEIL, FLOOR, DSZ, ISZ, D>R, R>D, EMGAM, GSB, LNBETA, LNGAMMA, MAX, MIN, NOP, REAL, RJ, W and WINV, ZETA, %+ and %-; renamed the top left keys B, C, and D, and bottom left EXIT. |
| 1.3 | 17.1.09 | Added AIP, ALENG, ARCL, AROT, ASHF, ASTO, ATOX, XTOA, AVIEW, CLA, PROMPT (all taken from 42S), CAPP, FC?C, FS?C, SGMNT, and the …# commands; renamed NBITS to BITS and STOWS to WSIZE; specified the bit commands closer; deleted the 4 carry bit operations. |
| 1.4 | 10.2.09 | Added CONST and a table of constants provided, D>J and J>D, LEAP?, %T, RCL and STO ▲ and ▼, and 2 forgotten statistics registers; deleted CHS, EMGAM, GSB, REAL and ZETA; purged and renamed the bit operations; renamed many commands. |
| 1.5 | 5.3.09 | Added RNDINT, CONV and its table, a memory table, the description of XEQ B, C, D to the operation index, and $a$ and $g_e$ to the table of constants; put CLSTK on a key, moved CLΣ and FILL, changed the % and log labels on the keyboard, put CLALL in X.FCN; checked and cleaned alpha mode keyboard and added a temporary alpha keyboard; rearranged the alphabet to put Greek after Latin, symbols after Greek consistently; separated the input and non-programmable commands; cleaned the addressing tables. |
| 1.6 | 12.8.09 | Added BASE, DAYS+, DROP, DROPY, E3OFF, E3ON, FC?F, FC?S, FIB, FS?F, FS?S, GCD, LCM, SETDAT, SETTIM, SET24, SINC, TIME, VERS, αDAY, αMONTH, αRC#; %Σ, as well as F-, t-, and $\chi^2$-distributions and their inverses; reassigned DATE, modified DENMAX, FLOAT, αROT, and αSHIFT; deleted BASE arithmetic, BIN, DEC, HEX, and OCT; updated the alpha keyboards; added flags in the memory table; included indirect addressing for comparisons; added a paragraph about the display; updated the table of indicators; corrected errors. |
| 1.7 | 9.9.09 | Added P.FCN and STAT catalogs, 4 more conversions, 3 more flags, Greek character access, CLFLAG, DECOMP, DENANY, DENFAC, DENFIX, Iβ, IΓ, αDATE, αRL, αRR, αSL, αSR, αTIME, 12h, 24h, fraction mode limits, normal distribution and its inverse for arbitrary μ and σ, and Boolean operations working within FLOAT; deleted αROT, αSHIFT, the timer, and forced radians after inverse hyperbolics; renamed WINV to $W^{-1}$, and beta and gamma commands to Greek; added tables of catalog contents; modified label addressing; relabeled PRGM to P/R and PAUSE to PSE; swapped SHOW and PSE as well as Δ% and % on the keyboard; relabeled Q; corrected CEIL and FLOOR; updated X.FCN and alpha commands; updated the virtual alpha keyboard. |
| 1.8 | 29.10.09 | Added R-CLR, R-COPY, R-SORT, R-SWAP, RCLM, STOM, alpha catalogs, 1 more constant and some more conversions, a table of error messages, as well as the binomial, Poisson, geometric, Weibull and exponential distributions and their inverses; renamed some commands; put $\sqrt{\ }$ instead of π on hotkey D. |
| 1.9 | 14.12.09 | Added two complex comparisons; swapped and changed labels in the top three rows of keys, dropped CLST; completed function descriptions in the index. |
| 1.10 | 19.1.10 | Added IMPFRC, PROFRC, $^{C}$ENTER, αBEG, αEND, and an addressing table for items in catalogs; updated temporary alpha mode, display and indicators, RCLM and STOM, alpha-commands and the message table; renamed the exponential distribution; wrote the introduction. |
| 1.11 | 21.9.10 | Changed keyboard layout to bring Π and Σ to the front, relabeled binary log, swapped the locations of π, CLPR, and STATUS, as well as SF and FS?; created a menu TEST for the comparisons removed and the other programmable tests from P.FCN; added %MG, %+MG, %MRR, RESET, SSIZE4, SSIZE8, SSIZE?, $^{C}$DROP, $^{C}$FILL, $^{C}$R↓, $^{C}$R↑, registers J and K, a table of contents and tables for stack mechanics and addressing in complex operations; updated memory and real number addressing tables, DECOMP, αOFF, αON, Π, and Σ; renamed ROUNDI, WSIZE?, β(x,y), Γ(x) and the constant $p_0$ ; deleted DROPY (use x⇔y, DROP instead), αAPP, αBEG, αEND, and the “too long error” message; deleted Josephson and von Klitzing constants (they are just the inverses of other constants included in CONST already); brought more symbols on the alpha keyboard. |
| 1.12 | 22.12.10 | Modified keyboard layout; added catalogs MODE and PROB; changed mode word, catalog contents and handling (XEQ instead of ENTER), as well as some non-programmable info commands; expanded IMPFRC and PROFRC; added a paragraph about the fonts provided and explained alpha catalogs in detail; added PRIME? and some conversions; deleted FRACT, OFF and ON. |
| 1.13 | 3.2.11 | Modified keyboard layout; modified αTIME, radix setting, H.MS+ and H.MS-; added EVEN?, FP?, INT?, LZOFF, LZON, ODD?, RCLS, STOS, returned FRACT; added and renamed some conversions; updated the paragraph about display; added appendices A and B; baptized the device WP 34S. |
| 1.14 | 18.3.11 | Added DEC and INC, renamed FLOAT to DECM; redefined αTIME and H.MS mode; updated appendix A; documented the annunciators BEG and = as well as underflows and overflows in H.MS; corrected some errors showing up with the emulator. |
| 1.15 | 21.3.11 | Modified FIX, removed ALL from MODE, updated CONV. |
| 1.16 | 27.3.11 | Added LBL?, f’(x), and f”(x); modified PSE; upgraded catalog searching. |
| 1.17 | ff | Added Cauch, Lgnrm, Logis and their inverses, all the pdf, COV, CUBE, CUBERT, ENGOVR, SCIOVR, SERRw, sw, sxy, TVM, xg, $\varepsilon$, $\varepsilon_m$, $\varepsilon_p$, σw, the polynomials, and three messages; renamed most cdf; killed H.MS mode; corrected errors. |

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