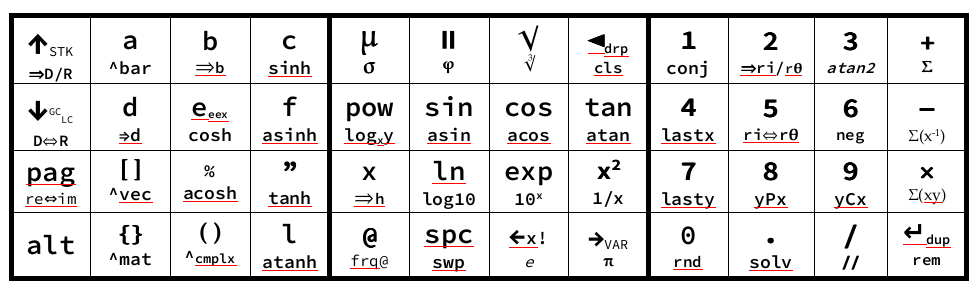
# Keywords, Commands on the PC Emulator

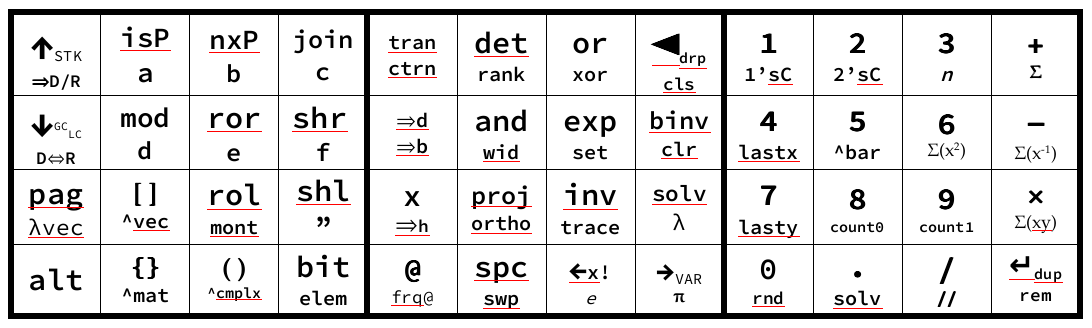
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| **Command** | **Type** | **Description** |
| *any literal* | data | Push a literal, the value of a variable or a string into the stack. If the literal is not a double precision number or a variable, it will be a bigint or a string (must be placed inside double quotes). All numbers are interpreted as decimal unless in quotes:  “xabcd” is a hex number (bigint)  “1234” is a decimal bigint.  “b1100” is a binary number.  1234.5e-6 is a decimal double precision number  “o7654” is an octal number. (not supported at present) |
| *num‘r’, ‘l’, ‘c’*  e.g., *4.7e-3l* | data | Any numeric literal followed by one of the characters‘r’, ‘l’ or ‘c’, indicating resistance, inductance or capacitance. The literal value will be stored on the stack but will be interpreted as an impedance value for a frequency in a variable called ‘f’. If variable ‘f’ doesn’t exist, a frequency value of 1Hz will be assumed.  For example, 4.7e-3l is the impedance of a 4.7mH inductor, or 29.531*j* ohms at 1000Hz. |
| (*numR numI*) | data | Push a double precision complex number with real part *numR* and imaginary part *numI* into the stack. |
| (*numI*) | data | Push a double precision imaginary number *numI* into the stack. |
| “a string” | data | Push a string, which can be an arbitrarily long decimal integer (a *bigint*) into the stack. If the string is a bigint, {+ - \* / max min > < >= <= = != } operators can be used. |
| @ | operator | Pop value in ToS-1 is popped into the variable name at ToS. |
| *var*@ | operator | Pop the ToS element in to a variable named *var*. |
| *n*@@ | operator | Pop *n* (must be a number ≥0) entities from the stack into the *acc* register where *n* is the value on the top of the stack. A vector or matrix is considered a single element and will be popped entirely. If the last entity is a vector, it will be popped into a variable that can be accessed using the variable name *vacc*. If *n* is 0, the entire stack will be cleared. If *n* is less than 0, no values will be popped and an error will result. The Execution Stack, which tracks conditionals will not be cleared (vector/matrices entry is also tracked using the execStack, will be adjusted after this operation). |
| [ *or* ] | data | Start or end a vector. |
| { *or* } | data | Start or end a matrix. |
| ( *or* ) | data | Encloses a complex number. |
| dup | operator | Duplicate the ToS. |
| swp | operator | Swap ToS with element prior to ToS. |
| if | conditional | Execute if the ToS element does not equal 0 or is a string. |
| el | conditional | Execute if the ToS element equals 0. |
| fi | conditional | End an if-el block |
| *label:* | label | A label used for jmp, jz or jnz. |
| jmp | unconditional jump | Jump to a label. |
| jz | conditional jump | Jump to a label if ToS is 0. |
| jnz | conditional jump | Jump to a label if ToS is not 0 or is a string. |
| + - \* /  max min  > < >= <= = != | operator | The usual arithmetic operators. Works for regular numbers (complex) or bigint strings. |
| % | operator | The percentage operator. Calculates ToS (‘x’) percentage of ToS - 1 (‘y’) |
| \_\_f*\** | Special variable | The internal write-only frequency variable, assigned as *numx* \_\_f@. Use the keystroke alt+@ on the calculator. The ‘\_’ is not available on the calculator. |
| // | operator | The parallel operator. |
| vec | operator | Accumulates all consecutive scalar elements between the ToS and the last barrier, vector or matrix or bottom of stack (BoS) into a vector. The ToS will be the last element and the element closest to the BoS will be the first. If the ToS is already a vector, then this command will split it into scalar elements. Use keystroke page 0 alt+[ function for this operation on the calculator. |
| mat | operator | Accumulates all consecutive vector elements between the ToS and the last barrier, scalar or matrix or bottom of stack (BoS) into a matrix (row order). The vector at ToS will be the last row and the vector closest to the BoS will be the first row of the matrix. If the ToS is already a matrix, then this command will split it into vector elements. Use keystroke page 0 alt+{ function for this operation on the calculator. |
| cmplx | operator | Creates a complex number with real part from (ToS - 1) and imaginary part from ToS (if both of these are real numbers). If the ToS is a complex or imaginary number then the real and imaginary parts are separated. Use keystroke page 0 alt+( function for this operation on the calculator. |
| bar | operator | Inserts or deletes a barrier at the current ToS element. A barrier stops accumulates of elements for the creation of a vector or matrix. If the current ToS is not a barrier, this command inserts a barrier; otherwise, it deletes the barrier at the ToS. |
| angle | operator | Toggles between degrees and radian modes. |
| coord | operator | Toggles between cartesian and polar modes. |
| rect | operator | Converts the number at ToS to rectangular (cartesian) coordinate system irrespective current coordinate system. |
| polar | operator | Converts the number at ToS to polar coordinate system irrespective current coordinate system |
| deg | operator | Converts the ToS to degrees. 1 radian = 57.295779513082320876798 degrees. |
| rad | operator | Converts the ToS to radians. 1 degree = 0.017453292519943295769237 radians. |
| bin | operator | Converts the ToS to binary. Ignore if the ToS is a binary bigint. |
| hex | operator | Converts the ToS to hex. Ignore if the ToS is a hex bigint. |
| dec | operator | Converts the ToS to decimal. Ignore if the ToS is a decimal bigint. |
| oct | operator | Converts the ToS to octal. Ignore if the ToS is an octal bigint. |
| reim | operator | Swaps the real an imaginary parts of the number at ToS.  1 reim gives (1) and (1) reim gives 1 |
| re | operator | Provides the real part of the complex number at ToS. |
| im | operator | Provides the imaginary part of the complex number at ToS. |
| neg | operator | Negates the number at ToS. |
| dupn*\** | operator | Duplicates the *x*th item from ToS, ToS is indexed as 0 and holds the value *x*. Negative or 0 values of *x* don’t change the stack. |
| recip | math function | Reciprocal of the ToS (computes 1/*x*). |
| rsum | vector operator | Sum of the reciprocal of the elements in the vector at ToS. |
| mean | vector operator | The mean computed over the elements in the vector at ToS. |
| sd | vector operator | The standard deviation computed over the elements in the vector at ToS. |
| var | vector operator | The variance (square of the standard deviation) computed from the values in the vector at ToS. |
| sqsum | vector operator | Sum of the squares of the elements in the vector at ToS. |
| sum | vector operator | Sum of the elements in the vector at ToS. |
| dot | vector operator | Sum of the product of the elements in the vector at ToS. The number of elements in the shorter vector determine how many products will be computed for the sum. |
| solv | matrix and vector operator | If ToS - 1 is a square matrix (not barred) and ToS is a vector, solves the simultaneous equation for the (matrix, vector).  If ToS - 1 is not a matrix or is a barred matrix, and ToS is a vector, solves the polynomial equation for the vector. |
| conj | math function | Complex conjugate of the number at ToS. |
| abs | math function | Absolute value of the number *x* at ToS, equals  *sqrt(sqr(real(x)) + sqr(imag(x)))*.  This is a shorthand for: cmplx 2 pow swp 2 pow + sqrt |
| arg | math function | Argument of the number *x* at ToS, equals  *atan(imag(x)/real(x))* |
| sqrt | math function | Square root of the ToS. |
| cbrt | math function | Cubic root of the ToS. |
| exp | math function | Computes *e* to the power of the number at ToS, where *e* is Euler’s constant (approximately, 2.718281828..). |
| log | math function | Natural logarithm of the number at ToS. |
| *pi*, *e* | data | Inserts the double precision approximation of *pi* or *e* to ToS. |
| log2*\** | math function | Logarithm of ToS to base 2. |
| log10 | math function | Logarithm of ToS to base 10. |
| logxy | math function | Logarithm of ToS -1 (‘y’) to base ToS (‘x’). |
| pow | math function | If ToS is a bigint and ToS - 1 is a real or bigint, computes the modular exponentiation of the bigint or integer at ToS - 1 with the bigint or integer exponent at ToS, modulo the modulus already set. If modulus has not been set or is 0, uses 264 as the modulus. In this context, pow is identical to exp. |
| sin, cos, tan, cot*\**, asin, acos, atan, acot*\** | trig function | Trigonometric functions. |
| sinh, cosh, tanh, coth*\**, asinh, acosh, atanh, acoth*\** | hyberbolic trig function | Hyperbolic trigonometric functions. |
| atan2 | trig function | Computes y x atan where *y* is the number at ToS - 1 and *x* is the number at ToS. |
| gcd, lcm | math function | Calculates the GCD and LCM of the vector at ToS. The result is a vector in the form [*gcd*, *lcm*]. |
| fac | math function | Factorial, *x*!, where *x* is the (integer part of the real part of the) number at ToS. |
| inv | matrix or bigint operation | Matrix inverse if ToS is a matrix. Modular inverse if ToS is a bigint or int. If matrix inverse doesn’t exist, returns an error.  For modular inverse, if the modulus is 0, uses 264 as the modulus. |
| det | matrix operation | Computes the determinant of the matrix at ToS. If the ToS does not have a matrix, reports an error. |
| iden | matrix operation |  |
| proj | matrix operation |  |
| trace | matrix operation |  |
| eival | matrix operation |  |
| eivec | matrix operation |  |
| tpose | matrix operation |  |
| rank | matrix operation |  |
| elem | matrix or vector operator | if ToS and ToS-1 are scalars and ToS-2 is a matrix, then returns the element  matrix(ToS-2)[row=ToS-1][col=ToS].  If ToS-1 is a vector and ToS is a scalar, then returns the scalar element  vector(ToS-1)[ToS].  If ToS-1 is a matrix and ToS is a scalar, then returns the row vector  matrix(ToS-1)[ToS] |
| mod | bigint or integer operation | Set the modulus for bigint or integer modular operations. Used for inv, exp (pow) , +, -, ⨯, and / operations on bigint or integer. If modulus has not been set, uses 264 as modulus. Modulus or width is required for the inv operation. |
| exp | complex, bigint or integer operation | If ToS is a bigint and ToS - 1 is a real or bigint, computes the modular exponentiation of the bigint or integer at ToS - 1 with the bigint or integer exponent at ToS, modulo the modulus already set. If modulus has not been set or is 0, uses 264 as the modulus. In this context, exp is identical to pow.  If the number *x* ToS is a real or complex number, computes *ex.* |
| mont | bigint or integer operation | The montgomery representation of the bigint or integer at ToS. |
| wid | bigint or integer operation | Set the width in bits for bigint or integer operations. Used in or, and, binv, xor, bit, shr, shl, ror, rol, count0, count1 and rnd operations. Optionally used for bigint operations such as exp, inv etc. if modulus is 0 (not set). |
| and, or, and, binv, xor, shr, shl, ror, rol | bigint or integer operation | Bitwise operation if ToS and ToS - 1 are bigints or integers. Returns an error if width is not set (default is 32 bits).  Shift right will extend the MS bit if the flasg signextend is set. Shift left will set zero in the LB bit position. |
| bit | bigint or integer operation | Test bit of number *y* atToS - 1 at position *x* (at ToS), returns 0 or 1. |
| count0, count1 | bigint or integer operation | Count the number of 0s or 1s in the binary representation of the bigint or integer at ToS. |
| 1’sC, 2’sC | bigint or integer operation | One’s or two’s complement of the bigint or integer at ToS. |
| set, clr | bigint or integer operation | Set or clear bit at position *x* (at ToS) in the number *y* at ToS - 1, returns 0 or 1. |
| isp, nxp | bigint or integer operation | isp returns a 1 is ToS has a prime number.  nxp returns the prime number after the number at ToS. |
| rnd | math operation |  |
| gl | integer or bigint operation | Calculates the GCD and LCM of the vector at ToS. The result is a vector in the form [*gcd*, *lcm*]. Can be bigint numbers (entered and displayed as strings). |
| lastx | math operation | The ToS value (*x*) before the last operation. |
| lasty | math operation | The ToS - 1 value (*y*) before the last operation. |
| ypx | integer operation | Computes yPx, where y is the integer number at ToS - 1 and x is at ToS. |
| ycx | integer operation | Computes yCx, where y is the integer number at ToS - 1 and x is at ToS. |
| hms | operator | Converts the real the number (or the real part of the complex number) at ToS to three numbers that are pushed into the stack: hours, minutes and seconds, these latter being the h:m:s representation of the number. If the current angle mode is radians, then the angle is converted to degrees first. |
| *\* not available on calculator hardware.* | | |

Default mode: Page 0



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| **Keystroke** | **Type** | **Description for Page 0** |
| **↑**STK  **⇒**D/R | primary | When pressed in compute mode, switches to stack inspection mode. In stack inspection mode, used as up cursor to point to various stack entries. |
| alternate | If the current angle mode is degrees, converts the number at ToS to radians. If the current angle mode is radians, convert to degrees. |
| **↓**GCLC  D⇔R | primary | When pressed in compute mode, calculates the GCD and LCM of the vector at ToS. The result is a vector in the form [*gcd*, *lcm*]. Can be bigint numbers (entered and displayed as strings). |
| alternate | Toggles the current angle mode between radians and degrees. Default at star tup is radians. |
| pag  re⇔im | primary | Cycles through the four page modes, mode 0 (default), mode 1 (additional math functions), mode α, the alphabet entry mode and mode π, the programming keyword mode and μ, the miscellaneous command mode. |
| alternate | Swaps the real and imaginary parts of the number at ToS. ToS must contain a real or complex number. |
| alt | primary | Cycles between primary, alternate and alternate-locked modes. |
| alternate | Not applicable. |
| a  ^bar | primary | The character ‘a’. |
| alternate | Toggle the barrier attribute on the element at ToS. |
| d  ⇒d | primary | The character ‘d’. |
| alternate | Convert the number at ToS to decimal representation. Only scalar elements are allowed. |
| [ ]  ^vec | primary | The character ‘[‘ that will start the entry of a vector. If a vector is already being entered, it will close it. |
| alternate | Accumulates all consecutive scalar elements between the ToS and the last barrier, vector or matrix or bottom of stack (BoS) into a vector. The ToS will be the last element and the element closest to the BoS will be the first. If the ToS is already a vector, then this command will split it into scalar elements. |
| {}  ^mat | primary | The character ‘{‘ that will start the entry of a matrix. If a matrix is already being entered, it will close it. |
| alternate | Accumulates all consecutive vector elements between the ToS and the last barrier, scalar or matrix or bottom of stack (BoS) into a matrix (row order). The vector at ToS will be the last row and the vector closest to the BoS will be the first row of the matrix. If the ToS is already a matrix, then this command will split it into vector elements. |
| b  ⇒b | primary | The character ‘b’. Use to begin a binary number. |
| alternate | Converts the ToS to binary representation. Only scalar elements are allowed. |
| eeex  cosh | primary | The character ‘e’. Also used to indicate than an exponent follows, e.g., 1.23e45 |
| alternate | Hyperbolic cosine. |
| %  acosh | primary | Calculates x% of y, where y is value at ToS-1 and x the value at ToS. |
| alternate | Inverse hyperbolic cosine. |
| ( )  ^cmplx | primary | The character ‘(‘ that will start the entry of a complex number. If a complex number is already being entered, it will close it. The closing parenthesis is optional and the complex number will be automatically closed. |
| alternate | Creates a complex number with real part from (ToS - 1) and imaginary part from ToS (if both of these are real numbers). If the ToS is a complex or imaginary number then the real and imaginary parts are separated. |
| c  sinh | primary | The character ‘c’. |
| alternate | Hyperbolic sine. |
| f  asinh | primary | The character ‘f’. |
| alternate | Inverse hyperbolic sine. |
| **”**  tanh | primary | Starts or closes a string (used for bigints). The closing quote is optional and will be automatically inserted. |
| alternate | Hyperbolic tangent. |
| l  atanh | primary | The character ‘l’, can be used as in a variable name or used to specify an inductive impedance. |
| alternate |  |
| μ  σ | primary | Inverse hyperbolic sine. |
| alternate | The standard deviation calculated over all the elements of the vector at ToS. |
| pow  logxy | primary | If ToS is a bigint and ToS - 1 is a real or bigint, computes the modular exponentiation of the bigint or integerat ToS - 1 with the bigint or integerexponent at ToS, modulo the modulus already set. If modulus has not been set or is 0, uses 264as the modulus. In this context, pow is identical to exp. |
| alternate | Logarithm of ToS -1 (‘y’) to base ToS (‘x’). |
| x  ⇒h | primary | The character ‘x’. Use to begin a hexadecimal number. |
| alternate | Converts the ToS to hex. Ignore if the ToS is a hex bigint. |
| @  frq@ | primary | Pop value in ToS-1 is popped into the variable name at ToS.  Use *var*@ to store into a variable named *var*. |
| alternate | Pop value in ToS-1 is popped into the internal frequency variable. This is used to calculate impedances. The number at ToS must be a real; if ToS has a complex number, then the real part will be used. |
| ⏸  φ | primary | Absolute value of the number *x* at ToS, equals  *sqrt(sqr(real(x)) + sqr(imag(x)))*.  This is a shorthand for: cmplx 2 pow swp 2 pow + sqrt |
| alternate | Argument of the number *x* at ToS, equals *atan(imag(x)/real(x))* |
| sin  asin | primary | Computes the sine of the number at ToS. |
| alternate | Computes the inverse sine of the number at ToS. |
| ln  log10 | primary | Computes the natural logarithm of the number at ToS. |
| alternate | Computes the logarithm to base 10 of the number at ToS. |
| spc  swp | primary | Enters the space character. Used to separate the real and imaginary portions of a complex number and the consecutive elements of a vector or matrix. |
| alternate | Swap ToS with element prior to ToS (at ToS - 1). |
| √  ∛ | primary | Computes the square root of the number at ToS. |
| alternate | Computes the cube root of the number at ToS. |
| cos  acos | primary | Computes the cosine of the number at ToS. |
| alternate | Computes the inverse cosine of the number at ToS. |
| exp  10x | primary | If ToS is a bigint and ToS - 1 is a real or bigint, computes the modular exponentiation of the bigint or integerat ToS - 1 with the bigint or integerexponent at ToS, modulo the modulus already set. If modulus has not been set or is 0, uses 264as the modulus. In this context, exp is identical to pow.  If the number *x at* ToS is a real or complex number, computes *ex.* |
| alternate | Computes 10x where *x* is the number at ToS. |
| **←**x!  *e* | primary | If a user entry is being entered/edited, then this key moves the cursor to the left.  If no entry is being edited, returns the factorial of the integer at ToS (or the integer portion of the complex number at ToS. The integer must be less than 210. |
| alternate | The approximate value of *e* — 2.718281828459045 |
| **◄**drp  cls | primary | If a user entry is being entered/edited, then this key deletes the character to the left of the cursor.  If the user is not editing an entry, drops the stack (removes the number or element at ToS). |
| alternate | Clears the stack. |
| tan  atan | primary | Computes the tangent of the number at ToS. |
| alternate | Computes the inverse tangent of the number at ToS. |
| x2  1/x | primary | Computes x2 where *x* is the number at ToS. |
| alternate | Computes x2 where *x* is the number at ToS. |
| **→**VAR  π | primary | If a user entry is being entered/edited, then this key deletes the character to the left of the cursor.  If the user is not editing an entry, this shows the detailed value of the element (number, vector or matrix) at ToS. |
| alternate | The approximate value of π — 3.141592653589793 |
| 1  conj | primary | The character ‘1’. |
| alternate | The complex conjugate of the element at ToS. |
| 4  lastx | primary | The character ‘4’. |
| alternate | The ToS value (*x*) before the last operation. |
| 7  lasty | primary | The character ‘7’. |
| alternate | The ToS - 1 value (*y*) before the last operation. |
| 0  rnd | primary | The character ‘0’. |
| alternate | Uses Pico hardware ring oscillators to generate random number — a 32-bit integer. |
| 2  ⇒ri/rθ | primary | The character ‘2’. |
| alternate | Changes the complex number at ToS (assumed to be rectangular format (re im) in rectangular mode and polar format (r *θ*) in polar mode) to polar or rectangular format respectively. |
| 5  ri⇔rθ | primary | The character ‘5’. |
| alternate | Toggles the complex number mode between rectangular and polar (default is rectangular). |
| 8  yPx | primary | The character ‘8’. |
| alternate | Computes yPx, where y is the integer number at ToS - 1 and x is at ToS. |
| .  solv | primary | The character ‘.’. |
| alternate | If ToS - 1 is a square matrix (not barred) and ToS is a vector, solves the simultaneous equation for the (matrix, vector).  If ToS - 1 is not a matrix or is a barred matrix, and ToS is a vector, solves the polynomial equation for the vector. |
| 3  atan2 | primary | The character ‘3’. |
| alternate | Computes y x atan where *y* is the number at ToS - 1 and *x* is the number at ToS. |
| 6  neg | primary | The character ‘6’. |
| alternate | Negates the number at ToS. |
| 9  yCx | primary | The character ‘9’. |
| alternate | Computes yCx, where y is the integer number at ToS - 1 and x is at ToS. |
| /  // | primary | The division operator. |
| alternate | The parallel operator. Computes *xy*/*(x* + *y)* where *x* is the number at ToS and *y* is the number at ToS - 1. |
| +  **Σ** | primary | The addition operator. |
| alternate | Sum of the elements in the vector at ToS. Same as the sum command on the emulator. |
| -  Σ(x-1) | primary | The subtraction operator. |
| alternate | Sum of the reciprocal of the elements in the vector at ToS. Same as the rsum command on the emulator. |
| ⨯  Σ(xy) | primary | The multiplication operator. |
| alternate | Sum of the product of the elements in the vectors at ToS and Tos - 1. Same as the dot command on the emulator. The number of elements in the shorter vector determine how many products will be computed for the sum. |
| ↵dup  rem | primary | If a user entry is being entered/edited, then pressing this key places the entry at ToS after lifting the stack. No operation takes place if the stack is full.  If the user is not editing an entry, then pressing this key duplicates the entry at ToS. |
| alternate | The remainder operator. |

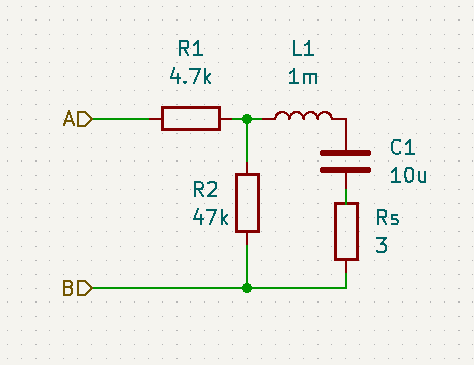
Numbers, Vectors and Matrices mode: Page 1



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| --- | --- | --- |
| **Keystroke** | **Type** | **Description** |
| **↑**STK  **⇒**D/R | primary | When pressed in compute mode, switches to stack inspection mode. In stack inspection mode, used as up cursor to point to various stack entries. |
| alternate | If the current angle mode is degrees, converts the number at ToS to radians. If the current angle mode is radians, convert to degrees. |
| **↓**GCLC  D⇔R | primary | When pressed in compute mode, calculates the GCD and LCM of the vector at ToS. The result is a vector in the form [*gcd*, *lcm*]. Can be bigint numbers (entered and displayed as strings). |
| alternate | Toggles the current angle mode between radians and degrees. Default at star tup is radians. |
| pag  λvec | primary | Cycles through the four page modes, mode 0 (default), mode 1 (additional math functions), mode α, the alphabet entry mode and mode π, the programming keyword mode. |
| alternate | Computes the eigenvector for the matrix at ToS. |
| alt | primary | Cycles between primary, alternate and alternate-locked modes. |
| alternate | Not applicable. |
| isp  a | primary | Returns 1 if the number at ToS is a prime, 0 otherwise. |
| alternate | The character ‘a’. |
| mod  d | primary | Sets the number (integer or bigint) at ToS as the modulus for bigint inverse and exponentiation operations |
| alternate | The character ‘d’. |
| [ ]  ^vec | primary | The character ‘[‘ that will start the entry of a vector. If a vector is already being entered, it will close it. |
| alternate | Accumulates all consecutive scalar elements between the ToS and the last barrier, vector or matrix or bottom of stack (BoS) into a vector. The ToS will be the last element and the element closest to the BoS will be the first. If the ToS is already a vector, then this command will split it into scalar elements. |
| {}  ^mat | primary | The character ‘{‘ that will start the entry of a matrix. If a matrix is already being entered, it will close it. |
| alternate | Accumulates all consecutive vector elements between the ToS and the last barrier, scalar or matrix or bottom of stack (BoS) into a matrix (row order). The vector at ToS will be the last row and the vector closest to the BoS will be the first row of the matrix. If the ToS is already a matrix, then this command will split it into vector elements. |
| nxp  b | primary | Returns the first prime number larger than the number at ToS. |
| alternate | The character ‘b’. Use to begin a binary number. |
| ror  e | primary | Bitwise rotate right assuming the number is *width* bits wide (default 64). |
| alternate | The character ‘e’. Also used to indicate than an exponent follows, e.g., 1.23e45. |
| rol  mont | primary | Bitwise rotate left assuming the number is *width* bits wide (default 64). |
| alternate | Converts the number (integer or bigint) at ToS to its Montgomery representation. |
| ( )  ^cmplx | primary | The character ‘(‘ that will start the entry of a complex number. If a complex number is already being entered, it will close it. The closing parenthesis is optional and the complex number will be automatically closed. |
| alternate | Creates a complex number with real part from (ToS - 1) and imaginary part from ToS (if both of these are real numbers). If the ToS is a complex or imaginary number then the real and imaginary parts are separated. |
| join  c | primary | Concatenates the vectors at ToS and ToS - 1 into a single vector. |
| alternate | The character ‘c’. |
| shr  f | primary | Bitwise shift right assuming the number is *width* bits wide (default 64). The leftmost bit can be extended from the carry bit or set to 0. |
| alternate | The character ‘f’. |
| shl  ” | primary | Bitwise shift left assuming the number is *width* bits wide (default 64). The carry bit can be assigned from the leftmost bit or remain unchanged. |
| alternate | Starts or closes a string (used for bigints). The closing quote is optional and will be automatically inserted. |
| bit  elem | primary | Checks bit value — *y x* bit — returns value of bit at position *x* in *y.* |
| alternate | If ToS and ToS-1 are scalars and ToS-2 is a matrix, then returns the element  matrix(ToS-2)[row=ToS-1][col=ToS].  If ToS-1 is a vector and ToS is a scalar, then returns the scalar element  vector(ToS-1)[ToS].  If ToS-1 is a matrix and ToS is a scalar, then returns the row vector  matrix(ToS-1)[ToS] |
| tran  ctran | primary | Transpose of the matrix at ToS. |
| alternate | Conjugate transpose of the matrix at ToS. |
| ⇒d  ⇒b | primary | Convert the number at ToS to decimal representation. Only scalar elements are allowed. |
| alternate | Convert the number at ToS to binary representation. Only scalar elements are allowed. |
| x  ⇒h | primary | The character ‘x’. Use to begin a hexadecimal number. |
| alternate | Converts the ToS to hex. Ignore if the ToS is a hex bigint. |
| @  frq@ | primary | Pop value in ToS-1 is popped into the variable name at ToS.  Use *var*@ to store into a variable named *var*. |
| alternate | Pop value in ToS-1 is popped into the internal frequency variable. This is used to calculate impedances. The number at ToS must be a real; if ToS has a complex number, then the real part will be used. |
| ⏸  φ | primary | inv: matrix inverse if ToS is a matrix. Modular inverse if ToS is a bigint or int.  binv: bitwise inverse if ToS is a bigint or int.  2’sC: same as neg (defined only for bigint or int), uses wid as bit-width.  wid: set width. Used in or, and, binv, xor, bit, shr, shl, ror, rol, count0, count1 and rnd operations. |
| alternate | Argument of the number *x* at ToS, equals *atan(imag(x)/real(x))* |
| sin  asin | primary | Computes the sine of the number at ToS. |
| alternate | Computes the inverse sine of the number at ToS. |
| ln  log10 | primary | Computes the natural logarithm of the number at ToS. |
| alternate | Computes the logarithm to base 10 of the number at ToS. |
| spc  swp | primary | Enters the space character. Used to separate the real and imaginary portions of a complex number and the consecutive elements of a vector or matrix. |
| alternate | Swap ToS with element prior to ToS (at ToS - 1). |
| √  ∛ | primary | Computes the square root of the number at ToS. |
| alternate | Computes the cube root of the number at ToS. |
| cos  acos | primary | Computes the cosine of the number at ToS. |
| alternate | Computes the inverse cosine of the number at ToS. |
| exp  10x | primary | If ToS is a bigint and ToS - 1 is a real or bigint, computes the modular exponentiation of the bigint or integerat ToS - 1 with the bigint or integerexponent at ToS, modulo the modulus already set. If modulus has not been set or is 0, uses 264as the modulus. In this context, exp is identical to pow.  If the number *x at* ToS is a real or complex number, computes *ex.* |
| alternate | Computes 10x where *x* is the number at ToS. |
| **←**x!  *e* | primary | If a user entry is being entered/edited, then this key moves the cursor to the left.  If no entry is being edited, returns the factorial of the integer at ToS (or the integer portion of the complex number at ToS. The integer must be less than 210. |
| alternate | The approximate value of *e* — 2.718281828459045 |
| **◄**drp  cls | primary | If a user entry is being entered/edited, then this key deletes the character to the left of the cursor.  If the user is not editing an entry, drops the stack (removes the number or element at ToS). |
| alternate | Clears the stack. |
| tan  atan | primary | Computes the tangent of the number at ToS. |
| alternate | Computes the inverse tangent of the number at ToS. |
| x2  1/x | primary | Computes x2 where *x* is the number at ToS. |
| alternate | Computes x2 where *x* is the number at ToS. |
| **→**VAR  π | primary | If a user entry is being entered/edited, then this key deletes the character to the left of the cursor.  If the user is not editing an entry, this shows the detailed value of the element (number, vector or matrix) at ToS. |
| alternate | The approximate value of π — 3.141592653589793 |
| 1  conj | primary | The character ‘1’. |
| alternate | The complex conjugate of the element at ToS. |
| 4  lastx | primary | The character ‘4’. |
| alternate | The ToS value (*x*) before the last operation. |
| 7  lasty | primary | The character ‘7’. |
| alternate | The ToS - 1 value (*y*) before the last operation. |
| 0  rnd | primary | The character ‘0’. |
| alternate | Uses Pico hardware ring oscillators to generate random number — a 32-bit integer. |
| 2  ⇒ri/rθ | primary | The character ‘2’. |
| alternate | Changes the complex number at ToS (assumed to be rectangular format (re im) in rectangular mode and polar format (r *θ*) in polar mode) to polar or rectangular format respectively. |
| 5  ri⇔rθ | primary | The character ‘5’. |
| alternate | Toggles the complex number mode between rectangular and polar (default is rectangular). |
| 8  yPx | primary | The character ‘8’. |
| alternate | Computes yPx, where y is the integer number at ToS - 1 and x is at ToS. |
| .  solv | primary | The character ‘.’. |
| alternate | If ToS - 1 is a square matrix (not barred) and ToS is a vector, solves the simultaneous equation for the (matrix, vector).  If ToS - 1 is not a matrix or is a barred matrix, and ToS is a vector, solves the polynomial equation for the vector. |
| 3  atan2 | primary | The character ‘3’. |
| alternate | Computes y x atan where *y* is the number at ToS - 1 and *x* is the number at ToS. |
| 6  neg | primary | The character ‘6’. |
| alternate | Negates the number at ToS. |
| 9  yCx | primary | The character ‘9’. |
| alternate | Computes yCx, where y is the integer number at ToS - 1 and x is at ToS. |
| /  // | primary | The division operator. |
| alternate | The parallel operator. Computes *xy*/*(x* + *y)* where *x* is the number at ToS and *y* is the number at ToS - 1. |
| +  **Σ** | primary | The addition operator. |
| alternate | Sum of the elements in the vector at ToS. Same as the sum command on the emulator. |
| -  Σ(x-1) | primary | The subtraction operator. |
| alternate | Sum of the reciprocal of the elements in the vector at ToS. Same as the rsum command on the emulator. |
| ⨯  Σ(xy) | primary | The multiplication operator. |
| alternate | Sum of the product of the elements in the vectors at ToS and Tos - 1. Same as the dot command on the emulator. The number of elements in the shorter vector determine how many products will be computed for the sum. |
| ↵dup  rem | primary | If a user entry is being entered/edited, then pressing this key places the entry at ToS after lifting the stack. No operation takes place if the stack is full.  If the user is not editing an entry, then pressing this key duplicates the entry at ToS. |
| alternate | The remainder operator. |

# Examples

Calculate the impedance between the terminals A and B in the diagram below at a frequency of 1kHz.



The full sequence:

1000 f@ 4.7e3r 1e-3l 10e-6c + 3 + 47e3 // +

Explanation:

* Enter the frequency

1000 f@

* Compute the impedance for the last loop as (3 -9.6323) = 3 - 9.6323*j* ohm

4.7e3r 1e-3l 10e-6c + 3 + 47e3 // +

* Compute the impedance for the parallel loops as (3.0018 - 9.631) = 3.0018 - 9.631*j* ohm

4.7e3r (3 -9.6323) 47e3 // +

* Compute the impedance in series with the first resistor as (4703.0018 -9.631) = 4703.0018 -9.631*j* ohm

4.7e3r (3.0018 -9.6311) +

Answer is **4703.0018 - 9.631*j*** ohm

# More Examples

500000000000000000000000000000002 **↵**

500000000000000000000000000000001 **-**

This results in:

0

However, when the numbers are entered as bigints, enclosed in quotes:

“500000000000000000000000000000002” **↵**

“500000000000000000000000000000001” **-**

results in:

1

# Keyboard Layouts

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ↑STK  ⇒D/R | a  ^bar | b  ⇒b | c  sinh | μ  σ | ⏸  φ | √  ∛ | ◄drp  cls | 1  conj | 2  ⇒ri/rθ | 3  *atan2* | +  Σ |
| ↓GCLC  D⇔R | d  ⇒d | eeex  cosh | f  asinh | pow  logxy | sin  asin | cos  acos | tan  atan | 4  lastx | 5  ri⇔rθ | 6  neg | -  Σ(x-1) |
| pag  re⇔im | [ ]  ^vec | %  acosh | ”  tanh | x  ⇒h | ln  log10 | exp  10x | x2  1/x | 7  lasty | 8  yPx | 9  yCx | ⨯  Σ(xy) |
| alt | {}  ^mat | ( )  ^cmplx | l  atanh | @  frq@ | spc  swp | ←x!  *e* | →VAR  π | 0  rnd | .  solv | /  // | ↵dup  rem |

Above: Default mode: Page 0

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ↑STK  ⇒D/R | isP  a | nxP  b | join  c | tran  ctrn | det  rank | or  xor | ◄drp  cls | 1  1’sC | 2  2’sC | 3  *n* | +  Σ |
| ↓GCLC  D⇔R | mod  d | ror  e | shr  f | ⇒d  ⇒b | and  wid | exp  set | binv  clr | 4  lastx | 5  ^bar | 6  Σ(x2) | -  Σ(x-1) |
| pag  λvec | [ ]  ^vec | rol  mont | shl  ” | x  ⇒h | proj  ortho | inv  trace | solv  λ | 7  lasty | 8  count0 | 9  count1 | ⨯  Σ(xy) |
| alt | {}  ^mat | ( )  ^cmplx | bit  elem | @  frq@ | spc  swp | ←x!  *e* | →VAR  π | 0  rnd | .  solv | /  // | ↵dup  rem |

Above: Numbers, Vectors and Matrices mode: Page 1

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **↑** | a  % | b  ” | c  @ | m  : | n | o | **◄** | 1 | 2 | 3 | + |
| **↓** | d | e | f | p | q | r | s | 4 | 5 | 6 | - |
| pag | g  [ | h  ] | i  ( | x | t | u | v | 7 | 8 | 9 | ⨯ |
| alt | j  { | k  } | l  ) | w  y | spc  z | **←** | **→** | 0 | . | / | ↵ |

Above: Keyboard mode: Page α

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ↑ | a | b | c | ∶  gt | end  gte | exe | ◄drp  cls | 1 | 2 | 3 | + |
| ↓ | d | e | f | if | el  lt | fi  lte | eq  neq | 4 | 5 | 6 | - |
| pag | [  ] | % | ” | x | jmp | jnz | jpz | 7 | 8 | 9 | ⨯ |
| alt | {  } | (  ) | @ | y | spc  z | ←  *e* | →  π | 0 | . | / | ↵ |

Above: Programming mode: Page π (not implemented yet)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ↑STK  ⇒D/R | a  ^bar | b  ⇒b | c  sinh | get  yyyy | get  mm | day | ◄drp  cls | 1  conj | 2  ⇒ri/rθ | 3  *atan2* | +  Σ |
| ↓GCLC  D⇔R | d  ⇒d | eeex  cosh | f  asinh | get  latt | get  longt | get  timez | tan  atan | 4  lastx | 5  ri⇔rθ | 6  neg | -  Σ(x-1) |
| pag  re⇔im | [ ]  ^vec | %  acosh | ”  tanh | get  mode | get  prec | get  mod | x2  1/x | 7  lasty | 8  yPx | 9  yCx | ⨯  Σ(xy) |
| alt | {}  ^mat | ( )  ^cmplx | l  atanh | @  frq@ | spc  swp | ←x!  *e* | →VAR  π | 0  rnd | .  solv | /  // | ↵dup  rem |

Above: Miscel mode: Page μ