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# COMMODORE 64

# MICRO GUIDE

A Quick Reference Guide to the BASIC AND SYSTEM OPERATIONS of the

# COMMODORE 64

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# MICROGUIDE
## FOR THE
# COMMODORE 64

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London

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## COMMODORE KEYWORDS

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## CONVENTIONS

**Expression**
Any legal combination of constants, variables, functions, and arithmetic operators.

**Line number**
Any number between 1 and 63999 at the beginning of the line which serves to identify the information on the line as a statement.

**List**
A one dimensional array.
example:
A(15), A$(20)

**Number**
A positive or negative decimal quantity which is significant to about eight digits, and whose magnitude is between a minimum of
$\pm 2.93873588\,E-39 \approx \pm 3\times 10^{-39}$
and maximum of
$\pm 1.70141183E+38 \approx \pm 1.7\times 10^{+38}$
Numbers larger than $1.7\times 10^{+38}$ produce an OVERFLOW ERROR, and numbers smaller than $2.938\times 10^{-39}$ are taken as zero.

**Numeric variable**
Numeric variables are used to name a numeric value or a collection of numeric values. Two types:–

**1** Real variable – may be represented by any set of alpha numeric characters (only the first two are recognised by computer) provided
(i) they start with a letter
(ii) they do not start with a BASIC keyword.

**2** Integer variables – are distinguished by having a % sign after the name. Numbers between +32767 and −32767 are stored with complete accuracy.
Examples:
SUN, SUM, AGE, A, A1 are real variables. Note: SUM and SUN will be the same variable name as far as the computer is concerned. A%, AREA%, ABC% are integer variable names. Note that names like TOTAL, LENGTH and other basic keywords cannot be used as a variable name.

**String**
A sequence of characters each of which is a letter, digit, space or some character other than a carriage return. ASCII code used to represent these characters in computer.

**String constant**
A string enclosed in double quotes.
Example: "COMMODORE 64"

**String variable**
Used to store strings. The rules for naming string variables are similar to those for numeric variables, except that the variable name must be followed by a dollar sign "$".
Examples:
NAME$, A$, A1$, CITY$

**Substring**
Any set of consecutive characters taken in sequence from the parent string.
Example:
A$="COMPUTER", "PUT" is a substring.

**Table**
A two- or multi-dimensional array.

| | |
|---|---|
| add | address (0-65535) |
| n, m | numbers |
| dn | device number (0-8) |
| fn | file number (0-127) |
| ln | line number (0-63999) |
| S | string |
| V | numeric string |
| V$ | string variable |
| [ ] | optional item |

## ARITHMETIC AND LOGIC OPERATIONS

**Arithmetic operators**

| symbol | operation | priority |
|---|---|---|
| + | addition | 4 |
| − | subtraction | 4 |
| * | multiplication | 3 |
| / | division | 3 |
| − | unary minus | 2 |
| ↑ | exponentiation | 1 |

**Logical operators**

**AND**

Combines relations so that (condition 1) AND (condition 2) is only TRUE when both conditions are true.
Example:
IF X>1 AND X<10 THEN PRINT "BETWEEN 1 AND 10".
Also used as a bitwise operator for binary numbers.
Example:
PRINT 85 AND 28 gives 20

| | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | |
|---|---|---|---|---|---|---|---|---|---|
| 85 in binary is | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | |
| 28 in binary is | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | |
| 85 AND 28 is | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | =20 |

**NOT**

Logically gives reverse of expression.
Example:
IF NOT (A=B) THEN PRINT "NOT EQUAL"
Also used as bitwise operator.
Example:
PRINT NOT 56 gives −57
PRINT NOT 6 gives −7

**OR**

Combines relations so that (condition 1) OR (condition 2) is TRUE when either or both conditions are true.
Example:
IF X>0 or Y>0 THEN PRINT "ONE OR BOTH +VE".
Also used as bitwise operator.
Example:
PRINT 85 OR 28 gives 93

| | 128 64 32 16 8 4 2 1 |
|---|---|
| 85 | 0 1 0 1 0 1 0 1 |
| 28 | 0 0 0 1 1 1 0 0 |
| | 0 1 0 1 1 1 0 1 = 93 |

**Relational operators**

| Symbol | Operation |
|---|---|
| = | equal to |
| < | less than |
| <= | less than or equal to |
| <> | not equal to |
| > | greater than |
| >= | greater than or equal to |

## CONTROL KEYS

**Display modes**

**Mode 1**
Upper case/Graphics – obtained on switching on

**Mode 2**
Upper case/lower case – obtained by depressing [THE COMMODORE KEY] [SHIFT] keys once; depressing keys again will set the display to mode 1 (ie toggles between mode 1 and mode 2).

**[CRSR]** ↓

Moves cursor down.

**[CRSR]** →

Moves cursor right.

**[SHIFT] [CRSR]** ↑

Moves cursor up.

**[SHIFT] [CRSR]** ←

Moves cursor left.

**[CTRL] [number key]**
Sets text colour, and performs certain operations.
(see table 1).

**[INST/DEL]**
Erases previous character

**[SHIFT] [INST/DEL]**
Allows insertion.

**[CLR/HOME]**
Moves cursor to top left hand corner of screen.

**[SHIFT] [CLR/HOME]**
Clears screen and moves cursor to top left hand corner of screen.

**[RETURN]**
Causes command to be acted upon.

**[RUN/STOP]**
Stops program execution or stops loading program.

**[SHIFT] [RUN/STOP]**
Automatically loads program on tape into memory and executes it.

**[RUN/STOP] [RESTORE]**
Clears screen and restores the computer to normal state. Memory remains unchanged. The Commodore key loads program into memory after FOUND program is displayed on the screen in response to LOAD command.

**[ C= ][key]**
Gives graphics character on left of key when in upper/lower case mode.

**[ C= ] [number key]**
Sets the additional text colours (see table 1).

**[SHIFT]**
Normal standard typewriter.
upper case/lower case mode – upper case character
upper case/graphics mode – graphics character on right side of key.

Table 1
**[CTRL][9]**
Inverse video.

**[CTRL][0]**
Normal video.

**Text colours**

| Keys | Colour | Code |
|---|---|---|
| [CTRL] [1] | BLACK | 144 |
| [CTRL] [2] | WHITE | 5 |
| [CTRL] [3] | RED | 28 |
| [CTRL] [4] | CYAN | 159 |
| [CTRL] [5] | PURPLE | 156 |
| [CTRL] [6] | GREEN | 30 |
| [CTRL] [7] | BLUE | 31 |
| [CTRL] [8] | YELLOW | 158 |
| [ C= ] [1] | ORANGE | 129 |
| [ C= ] [2] | BROWN | 149 |
| [ C= ] [3] | LIGHT RED | 150 |
| [ C= ] [4] | GREY 1 | 151 |
| [ C= ] [5] | GREY 2 | 152 |
| [ C= ] [6] | LIGHT GREEN | 153 |
| [ C= ] [7] | LIGHT BLUE | 154 |
| [ C= ] [8] | GREY 3 | 155 |

## OPERATING COMMANDS

**CONT**
Continues program execution that is interrupted by pressing [RUN/STOP], STOP statement, or END statement. The execution continues from the line of interrupt.

**LIST [In - Im]**
Produces a listing of the program between lines In and Im inclusive. Default on In is first line and on Im is last line.
Examples:

| | |
|---|---|
| LIST | lists whole program |
| LIST 200– | lists line 200 onwards |
| LIST 200–300 | lists lines 200 to 300 |
| LIST –100 | lists upto line 100 |
| LIST 100 | lists line 100 |

**LOAD p, dn**
Loads program p from device dn. The default for dn is 1, ie tape. Printer is device 4 and disc is 8.
Examples:
Load loads the next program on tape
LOAD "PROG" searches for PROG on tape and loads it when found.
LOAD "PROG",8 loads the specified program from disc.
LOAD "*",8 loads the first program on disc.

**NEW**
Clears computer memory, ie deletes program and variables.

**RUN In**
Executes program in memory from the specified line number. Default for In is lowest line number. Direct command GOTO In has the same effect.

**SAVE p, dn, m**
Saves program p on device dn with end-of-tape marker if m=1 (ie if m=0 no end-of-tape marker). Default on dn is 1, ie tape. Disc is 8.
Examples:
SAVE "PROG" saves PROG on tape
SAVE "PROG",8 saves PROG on disc
SAVE A$ saves program whose name is A$ on tape
SAVE "PROG",1,1 saves PROG on tape with an end-of-tape marker at the end of program

**VERIFY p, dn**
Checks program on disc or tape against the one in memory, ie checks if program is SAVEd.
Examples:
VERIFY "PROG",8 checks for file PROG on disc
VERIFY "PROG" checks for file PROG on tape
VERIFY checks next program on tape

**CLR**
Clears all variables from memory, leaving the program in memory unchanged.

**DATA d1, d2, d3 . . .**
Provides constant data (numbers or strings) for READ statement
Example:
```
10  FOR I = 1 TO 5
20  READ A(I):NEXT I
30  DATA 35.0,−20.0, 7.25, −2.5, 18.0
    assigns 35.0 to A(1), −20.0 to A(2), and so on.
```

**DEF FNV(dv)=expression**
Defines a user-specified function, where V is any legal variable name (upto two characters long). The dummy variable dv is a letter which will be replaced by the function argument when the function is called.
Example:
```
10  DEF FNA(X) = X*X+1
20  Y=3 : B = FNA(Y) : PRINT B
```
Prints 10 on the screen. This is because the dummy variable X is replaced by the value of Y, and the expression is evaluated when the function FNA is called at line 20.

**DIM V[$](k[,m])**
Specifies storage space to be allocated for list or table V[$]. If a list or a table is not specified by DIM statement, the default for K (number of rows) is 10, and the default for m (number of columns) is 10. That means the list has 10 elements in it and the table has 10 rows and 10 columns (100 elements).
Examples:
```
10  DIM A(5)
```
reserves storage for six elements in numeric list A. Note zeroth element.
```
10 DIM X(9, 19), XY$(9, 9)
```
reserves storage for 10 rows and 20 columns for numeric table X, and, 10 rows and 20 columns for string table XY.

**END**
Indicates the end of program and is usually the statement with the highest line number.

**FOR V = k TO m [STEP s]**
Specifies a loop and must be used with a NEXT statement. The loop is executed for a range of specified by k and m.
s indicates increment in step (ie next n=n+s), and if omitted default is 1. k, m and s may be numbers or variables (numeric).
Examples:
```
10  FOR I=1 to 20
20  PRINT I:NEXT I
30  FOR J= 0 TO 2 STEP 0.2
40  PRINT J:NEXT J
```
line 20 prints 1, 2, 3, . . . . 20
line 40 prints 0, 0.2, 0.4, . . . . 1.8

**GET V$**
Allows inputting data from the keyboard one letter or number at a time. The character entered is assigned to the string variable V$.
Example:

```
10  GET A$
20  IF A$="" GOTO 10
30  PRINT A$
```

line 20 checks if a key is pressed: if it is , prints the key, otherwise waits until a key is pressed.

**GET #d, V$**
Inputs one character at a time from a previously opened data file on device d, and assigns the character entered to the variable V$.
Example:

```
10  GET#1,A$
```

inputs one character from the opened date file and assigns it to A$.

**GOSUB ln**
Enters a subroutine at the specified line. The subroutine is exited by executing a RETURN statement which returns control to the line following the GOSUB call.
Example:

```
100    GOSUB 1000
110
.
.
.
200    STOP
1000   REM SUBROUTINE
.
.
.
1100   RETURN
```

**GOTO ln**
Transfers control to the statement at the specified line.

```
10  GOTO 50
```

**IF condition THEN statement**
The condition is evaluated and control is transferred to the statement following THEN if condition is true. If condition is not true, then control is transferred to the next line.
Example:

```
100  IF A$<>"E" THEN[GOTO]10
110  END
```

**INPUT ["PROMPT";]V[$]**
Allows data to be entered from the keyboard. This statement, unlike the GET statement, causes a "?" to be output on the screen so that you can respond by typing in values for the requested variables.

**LET V[$]=expression**
Assigns value of the expression to the variable V. The word LET may be omitted.

Examples:
```
10  LET A=3.5
20  B=A*3+A↑2
```

**NEXT V[,V]**
Terminates FOR . . . NEXT loop (see FOR) if the limit of loop is reached. If loop is not finished, the loop variable V is incremented by the specified step value. If more than one variable is given, they are completed in order from left to right.
Examples:
```
10    FOR I=1 to 10
20    FOR J=10 to 20
.
.
.
100   NEXT J      or 100 NEXT J, I
110   NEXT I
```

**ON NV GOSUB ln1, ln2, ln3, . . .**
**GOTO**
Allows several possible transfers of control to a subroutine or a line depending on the value of NV.(Numeric variable)
Examples:
```
30      ON X GOTO 100, 200, 300
        will cause control to move to line 100
        if X =1, line 200 if X=2, and line 300
        if X=3
40      ON X GOSUB 1000, 3000
        transfers control to subroutine at line
1000    if X=1, and subroutine at line
3000    if X=2
```

Example:
```
10  PRINT A;SPC(10);B
```
Prints value of A, inserts 10 spaces and prints value of B.

**READ V1[$],V2[$], . . .**
Assigns the data (numeric or string) in DATA statement to the specified variables. This statement must be used with at least one DATA statement.
Example:
```
 10  READ A$, B, C, D%
.
.
.
100  DATA SMITH, 3.5, 2.6, 25
```

**REM**
Inserts comment lines in the program. Everything after REM is ignored by the computer.
Example:
```
1000  REM **SUB1**
```

**RESTORE**
Allows data in DATA statements to be read more than once. That

is, it sets the data block pointer back to the beginning of the collection of data values.
Example:
100 RESTORE
sets data pointer to first data item in the program.

**RETURN**
Exits subroutine and transfers control to the statement following the last GOSUB from which it transferred. A subroutine must have at least one RETURN statement (see GOSUB).

**POKE add, n**
Is a command that alters the contents of the specified memory location (ie add) to the value specified by n (0-255). The addresses (add) that can be POKEd are between 0 and 65535.
Example:
POKE 1024,4 2 puts * (ASCII 42) in memory location 1024.

**PRINT["prompt";V[,V]]**
Types out results of computation, messages and/or types out blank line. The results tobe printed are separated by format control characters. These characters are:
Comma "," – causes the output to be printed in the next print zone (four print zones on a line).
Semicolon ";" – causes the output to be printed in a close packed form (ie print position remains at the end of last print).
Examples:
10 PRINT Prints blank line
20 PRINT "AVERAGE=";AVR prints the message inside quotes followed by value of AVR
30 PRINT A+B, A−B prints the sum of A and B and the result of subtracting B from A in the next print zone.

**PRINT TAB(n);V**
Types out results of computation, messages, etc, at column n.
Example:
10 PRINT TAB(5);A
prints value of A in column 5.

**PRINT SPC(n);V**
Types out results, etc after n spaces from the current print position.

**STOP**
Breaks program execution at line containing the STOP statement. Program execution can be resumed by typing CONT [ENTER], which will continue execution from the line following the STOP statement.

**SYS(add)**
Executes machine language program starting at address specified by add (between 0 and 65535).

**WAIT add,V1[,V2]**
Takes the contents of the memory location given by add, and XORs it with the second variable V2 and ANDs the result with the

first variable V1. If result is zero then the process is repeated until result is non zero, in which case next statement is executed.
Example:
```
10 POKE 198,0
20 WAIT 198,1
30 PRINT "OK"
```
waits until a key is pressed, and then prints OK.

## BASIC FUNCTIONS

### Section A: Numeric and Trigonometric Functions

**ABS(n)**
Returns the absolute value of n (ignores the sign).
Example:
PRINT ABS(−3.5) Prints 3.5
PRINT ABS(A*B) Prints absolute value of A×B

**ATN(n)**
Returns the arctangent (ie $\tan^{-1}$) of n in radians.

**COS(n)**
Returns the cosine of angle n given in radians.

**EXP(n)**
Returns the result of e(2.718) to the power of n.

**FRE(n)**
Returns the number of free bytes available, regardless of what value n has.

**INT(n)**
Returns the integer part of n (ie removes decimal fraction)
Example:
PRINT INT(2.99) Prints 2
PRINT INT(−2.01) Prints −3

**LOG(n)**
Returns the logarithm to base e (ie natural log) of n.

**PEEK(add)**
Returns the contents of the specified memory location (0-65535).

**POS(n)**
Returns the column number of the print position on the screen, regardless of what value n has.

**RND(n)**
Returns random whole number between 0 and 1. If n is zero, the random number generated will be the same as the last one. If n is not zero the generated number will be different.
Example:
PRINT INT(6*RND(1)) prints a random number between 1 and 5.

**SGN(n)**
Determines whether n is positive, zero or negative. It returns
−1 if n is negative
0 if n is zero
1 if n is positive

**SIN(n)**
Returns the sine of angle n given in radians.

**SPC(n)**
Used with PRINT statement to move the print position n space forward.
Example:
PRINT SPC(5);"COMMODORE"
Prints COMMODORE after moving five spaces forward.

**SQR(n)**
Returns square root of n (will produce error if n is negative).

**TAB(n)**
Used with PRINT statement to move the print position to the specified column of the current line.
Example:
PRINT TAB(10);"COMPUTER"
prints COMPUTER at column 10 of the current line.

**TAN(n)**
Returns the tangent of n given in radians.

**USR(n)**
Transfers control from BASIC to machine language routine whose address is given by the contents of memory locations 784 and 785 (user function jump). The parameter n is passed to the machine language programme, and returns a value back to BASIC program.

## SECTION B: STRING FUNCTIONS

**ASC(s)**
Gives the ASCII code number for the first character of the string s.
Example:
PRINT ASC("COMP")
gives ASCII value of C which is 67
PRINT ASC(A$)
gives ASCII value of first character in A$.

**CHR$(n)**
Returns the character whose ASCII code is given by n (0-255).
Example:
CHR$(70) gives character F.

**LEFT$(S, n)**
Returns a substring of string S. The substring begins at the leftmost character of the string S and contains the number of characters specified by n.
Example:
```
10  LET A$="ABCDEFGH"
20  PRINT LEFT$(A$,5)
```
Prints ABCDE

**LEN(S)**
Returns the number of characters in the string.
Example:
```
PRINT LEN("COMPUTER")
```
Prints 8

**MID$(S, n, m)**
Returns the substring of string S, starting at character position specified by n, and containing the number of characters specified by m. If m is omitted the substring will continue to the end of string S.
Example:
```
MID$("STRING",2,3)
```
will give "TRI".

**RIGHT$(S, n)**
Returns a substring of the string S, which ends at the rightmost character of the string s and contains n characters.

**STR$(n)**
Returns the string representation of n (ie converts numbers to strings).
Example:
```
10  LET A$="DECEMBER▽" + STR$(26)
```
A$ will contain "DECEMBER▽26". Note: ▽ stands for space.

**VAL(S)**
Returns the numeric characters of strings as a number (ie inverse of STR$)
Example:
```
NUM=VAL("1234")
```
assigns value 1234 to NUM
```
PRINT VAL("IB1234")
```
prints 0
```
PRINT VAL("23.4GRAMS")
```
prints 23.4

## ERROR MESSAGES

**BAD SUBSCRIPT**
Value of the subscript is greater than the declared dimension.

**CAN'T CONTINUE**
Program execution will not continue by using CONT command eg error occurred during last execution, or a line has been edited since.

**DEVICE NOT PRESENT**
The specified I/O device is not connected to the computer.

**DIVISION BY ZERO**
Attempting to divide a number by zero.

**EXTRA IGNORED**
A comma is included in data item which is keyed in in response to an INPUT statement. Every item after the comma is ignored.

**FILE DATA**
String data was received from a data file when numeric data was expected.

**FILE NOT FOUND**
No such file on tape or disc.

**FILE NOT OPEN**
Using CLOSE, CMD, PRINT#, etc, statements without using an OPEN statement first.

**FILE OPEN**
Attempting to open a file that is already open.

**FORMULA TOO COMPLEX**
String expression needs to be broken into smaller parts for evaluation.

**ILLEGAL DIRECT**
Using a statement as a direct command, where it can only be used as a statement in program, eg INPUT A.

**ILLEGAL QUANTITY**
The specified parameters are out of the allowable range.

**LOAD**
Problems with the program on tape.

**NEXT WITHOUT FOR**
Incorrect FOR . . . NEXT loop, eg wrong index variable or incorrect nesting.

**NOT INPUT FILE**
Attempting to input or get data from a file that is specified as an output file.

**NOT OUTPUT FILE**
Attempting to output data into file that is specified as an input file.

**OUT OF DATA**
Attempting to read more data when the data block pointer has reached the end of data.

**OUT OF MEMORY**
All available RAM is being used by the program and variables. Can also be caused by having too many GOSUBS or nesting too many FOR loops.

**OVERFLOW**
Number too large to be handled by computer (maximum value $\approx \pm 1.7 \times 10^{38}$):

**REDIM'D ARRAY**
Attempting to redimension an array. Arrays can only be dimensioned once.

**REDO FROM START**
Attempting to input character data during an input, when numeric data is expected. Re-enter correct data.

**RETURN WITHOUT GOSUB**
Caused by entering into a subroutine without using a GOSUB statement, eg using GOTO.

**STRING TOO LONG**
More than 255 characters in string.

**SYNTAX ERROR**
Unrecognisable command, eg misspelling, incorrect punctuation.

**TYPE MISMATCH**
Assigning string data to numeric variable or vice-versa.

**UNDEF'D FUNCTION**
Failure to define referenced user defined function (use DEF FN to define function).

**UNDEF'D STATEMENT**
Attempting to branch to a line which does not exist.

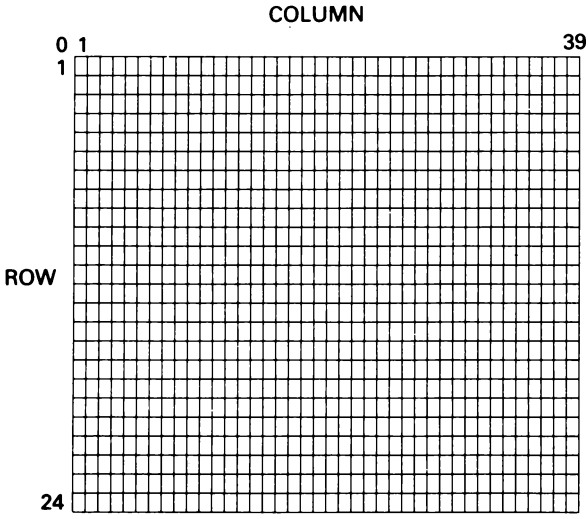
**VERIFY**
Program on tape or disc does not match program currently in memory.

## SCREEN DISPLAY

**Two modes of Display:**
1 Upper case/Graphics POKE 53272,29 Switches to mode i.
2 Upper case/Lower case POKE 53272,31 Switches to mode ii.

Two POKE statements are required to put a character on the screen.
1 POKE screen character code into screen memory (address 1024-2023).
2 POKE colour code into colour memory (address 55296- 56295), corresponding to the same row and column on screen memory.

| | Screen memory location | Colour memory location |
|---|---|---|
| Top left of screen 0th row and 0th column | 1024 | 55296 |
| Top right of screen 0th row and 39th column | 1063 | 55355 |
| . . . and so on until . . . | | |
| Bottom left of screen 24th row and 0th column | 1984 | 56256 |
| Bottom right of screen 24th row and 39th column | 2023 | 56295 |




Example:
10 POKE 1024+12+40*20 , 83 (83 code for heart)
20 POKE 55296+12+40*20 , 2 (2 code for red)
Puts a red heart at column 12 row 20 on the screen.

**Colour codes**

Sixteen colours are available.

| Colour | Code |
|---|---|
| Black | 0 |
| White | 1 |
| Red | 2 |
| Cyan | 3 |
| Purple | 4 |
| Green | 5 |
| Blue | 6 |
| Yellow | 7 |
| Orange | 8 |
| Brown | 9 |
| Light Red | 10 |
| Grey 1 | 11 |
| Grey 2 | 12 |
| Light Green | 13 |
| Light Blue | 14 |
| Grey 3 | 15 |

## SCREEN DISPLAY CHARACTERS AND CODES

| POKE | SET 1 | SET 2 | POKE | SET 1 | SET 2 | POKE | SET 1 | SET 2 |
|---|---|---|---|---|---|---|---|---|
| 0 | @ | @ | 21 | U | u | 42 | * | |
| 1 | A | a | 22 | V | v | 43 | + | + |
| 2 | B | b | 23 | W | w | 44 | , | , |
| 3 | C | c | 24 | X | x | 45 | - | - |
| 4 | D | d | 25 | Y | y | 46 | | |
| 5 | E | e | 26 | Z | z | 47 | / | / |
| 6 | F | f | 27 | [ | [ | 48 | 0 | 0 |
| 7 | G | g | 28 | £ | £ | 49 | 1 | 1 |
| 8 | H | h | 29 | ] | ] | 50 | 2 | 2 |
| 9 | I | i | 30 | ↑ | ↑ | 51 | 3 | 3 |
| 10 | J | j | 31 | ← | ← | 52 | 4 | 4 |
| 11 | K | k | 32 | SPACE | SPACE | 53 | 5 | 5 |
| 12 | L | l | 33 | ! | ! | 54 | 6 | 6 |
| 13 | M | m | 34 | " | " | 55 | 7 | 7 |
| 14 | N | n | 35 | # | # | 56 | 8 | 8 |
| 15 | O | o | 36 | $ | $ | 57 | 9 | 9 |
| 16 | P | p | 37 | % | % | 58 | | |
| 17 | Q | q | 38 | & | & | 59 | ; | ; |
| 18 | R | r | 39 | ' | ' | 60 | < | < |
| 19 | S | s | 40 | ( | ( | 61 | = | = |
| 20 | T | t | 41 | ) | ) | 62 | > | > |

| POKE | SET 1 | SET 2 | POKE | SET 1 | SET 2 | POKE | SET 1 | SET 2 |
|---|---|---|---|---|---|---|---|---|
| 63 | ? | ? | 85 |  | U | 107 |  |  |
| 64 |  |  | 86 |  | V | 108 |  |  |
| 65 |  | A | 87 |  | W | 109 |  |  |
| 66 |  | B | 88 |  | X | 110 |  |  |
| 67 |  | C | 89 |  | Y | 111 |  |  |
| 68 |  | D | 90 |  | Z | 112 |  |  |
| 69 |  | E | 91 |  |  | 113 |  |  |
| 70 |  | F | 92 |  |  | 114 |  |  |
| 71 |  | G | 93 |  |  | 115 |  |  |
| 72 |  | H | 94 |  |  | 116 |  |  |
| 73 |  | I | 95 |  |  | 117 |  |  |
| 74 |  | J | 96 | SPACE | SPACE | 118 |  |  |
| 75 |  | K | 97 |  |  | 119 |  |  |
| 76 |  | L | 98 |  |  | 120 |  |  |
| 77 |  | M | 99 |  |  | 121 |  |  |
| 78 |  | N | 100 |  |  | 122 |  |  |
| 79 |  | O | 101 |  |  | 123 |  |  |
| 80 |  | P | 102 |  |  | 124 |  |  |
| 81 |  | Q | 103 |  |  | 125 |  |  |
| 82 |  | R | 104 |  |  | 126 |  |  |
| 83 |  | S | 105 |  |  | 127 |  |  |
| 84 |  | T | 106 |  |  | | | |

Codes from 128-255 are reversed images of codes 0-127.

## GRAPHICS

**Modes are:**

**1 Character mode**
Taken on switch on, and allows to display all the available symbols on the keyboard. Symbol size is 8 pixels by 8 pixels.

**2 High-resolution (bit-map) mode**
64000 individually controllable pixels. That is 320 pixels across by 200 pixels down.
Memory requirement 8K (64000/8), where 8 is the number of bits per byte

To put 64 into high resolution mode use:
POKE 53265, PEEK (53265) OR 32
To get out of high-resolution mode use:
POKE 53265, PEEK (53265) AND 223

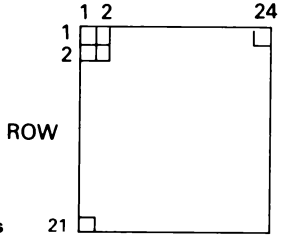
To assign 8K of memory for high-resolution screen use:
POKE 53272, PEEK (53272) OR 8
This moves the high-resolution screen map to locations 8192-16191 and colour screen map to location 1024-2023.
Example:

```
10  POKE 53265, PEEK (53265) OR 32
20  POKE 53272, PEEK (53272) OR 8
30  FOR I=8192 TO 16191:POKEI, 0:NEXT I
40  FOR I=1024 TO 2023:POKE I, 14;NEXT I
50  FOR I=12038 TO 12354:POKE I, 255:NEXT I
60  GOTO 40
```

line 30 clears the contents of memory locations (screen map) 8192-16191
line 40 sets the foreground and backgrounds colours. ie
16* foreground + background
16* 0 + 14 black, light blue
line 50 draws a black horizontal line in the middle of the screen

### 3 Sprites

A sprite is a graphics object, and is formed from 3 bytes (24 pixels) across by 21 bits (21 pixels) down. This requires 3×21=63 bytes of memory which forms a block, in which sprite data is stored.



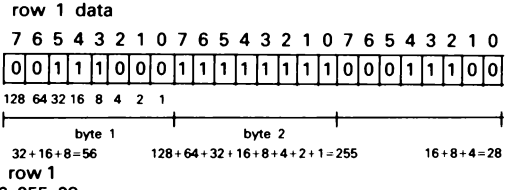

**Sprite registers**

| Memory location | Description |
|---|---|
| 53248 | Sprite 0 x position |
| 53249 | Sprite 0 y position |
| 53250-53263 | Sprites 1-7 x, y positions |
| 53264 | Most significant Bit of x position |
| 53265 | Bit-mapped mode and vertical pixel scrolling |
| 53266 | Raster register |
| 53267 | Light pen x position |
| 53268 | Light pen y position |
| 53269 | Turn sprite ON/OFF |
| 53270 | Multicolour character mode and horizontal pixel scrolling |
| 53271 | Sprite expands in y direction |
| 53272 | Character memory pointer |
| 53273 | Interrupt request |
| 53274 | Disable interrupt |
| 53275 | Sprite priority |
| 53276 | Multicolour sprite mode |
| 53277 | Sprite expands x direction |
| 53278 | Sprite/sprite collision |

| | |
|---|---|
| 53279 | Sprite/background collision |
| 53280 | Border colour |
| 53281 | Background colour 0 |
| 53282 | Background colour 1 |
| 53283 | Background colour 2 |
| 53284 | Background colour 3 |
| 53285 | Sprite multicolour 0 |
| 53286 | Sprite multicolour 1 |
| 53287-53294 | Colour for sprites 0-7 |

**To form a sprite:–**

i Work out the data for the required sprite and place it in a 64 byte block in memory starting at block 13 (ie address 13×64=832). Use DATA and READ statements for this purpose.
For example:




DATA 56, 255, 28, .....

ii Turn on the required sprite use:–
POKE53269, value where value is obtained from:

| sprite number | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| value | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

Example:
POKE 53269,4 turns on sprite 2
POKE 53269,46 turns on sprites 1, 2, 3 and 5.

iii Set sprite point to position where data to be read (ie which block?)

| memory location | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 |
|---|---|---|---|---|---|---|---|---|
| sprite | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Example:
POKE 2044, 13 indicates data for sprite.
iv Move the sprite on to screen.
POKE 0-255 into the required sprites x position address.
and POKE 0-255 into the required sprites y position address.
Example:
POKE 53256, 85
POKE 53257, 100
moves sprite 4 to point 85,100 on the screen.
v Add colour
Format is:–
POKE 53287-53294, Colour code (0-15)
Example:
POKE 53291,13 changes the sprite 4 colour to light green.

## SOUND

Creating sound on Commodore 64 is done with the aid of the 6581 SID (Sound Interface Device) chip. The 64 can generate three individual voices and one, two or all three can be played simultaneously (each having eight octaves, but there is one volume control for all three voices).
Sound on 64 is controlled by the POKE command, and the areas of the memory concerned with sound are 54272 to 54300.

**Voice 1**

| Memory location | | Action |
|---|---|---|
| **Decimal** | **HEX** | |
| 54272 | D400 | Low frequency value of note |
| 54273 | D401 | High frequency value of note |
| 54274 | D402 | Low pulse |
| 54275 | D403 | High pulse |
| 54276 | D404 | Waveform |
| 54277 | D405 | Attack/Decay |
| 54278 | D406 | Sustain/Release |
| **Voice 2** | | |
| 54279 | D407 | Low frequency value of note |
| 54280 | D408 | High frequency value of note |
| 54281 | D409 | Low pulse |
| 54282 | D40A | High pulse |
| 54283 | D40B | Waveform |
| 54284 | D40C | Attack/Decay |
| 54285 | D40D | Sustain/Release |
| **Voice 3** | | |
| 54286 | D40E | Low frequency value of note |
| 54287 | D40F | High frequency value of note |
| 54288 | D410 | Low pulse |
| 54289 | D411 | High pulse |
| 54290 | D412 | Waveform |
| 54291 | D413 | Attack/Decay |
| 54292 | D414 | Sustain/Release |
| 54293 | D415 | Low frequency cut-off (0-7) |
| 54294 | D416 | High frequency cut-off (0-255) |
| 54295 | D417 | Resonance (bits 4-7)<br>Filter voice, 1, bit 0 (turn off voice 1)<br>Filter voice 2, bit 1 (turn off voice 2)<br>Filter voice 3, bit 2 (turn off voice 3) |
| 54296 | D418 | Volume control for all three voices (bits 0-3). Volume value (0-15)<br>bit 4 low pass filter<br>bit 5 band pass filter<br>bit 6 high pass filter |
| 54297 | D419 | Access to output of envelope generator of voice 3 |
| 54299 | D41B | Digitized output from voice 3 |
| 54300 | D41C | Digitized output from envelope generator |

In order to create any sound, the following parameters must be set in the order specified.

**1** Volume:– You should POKE a value between 0 (lowest) and 15 (highest).
Example:
POKE 54296,15 sets volume to full.

**2** Attack/Decay:– Controls the rate at which the note rises to its peak volume. Each voice (1, 2 and 3) is set separately, but attack and decay are controlled by one register.

| AT4 | AT3 | AT2 | AT1 | DEC4 | DEC3 | DEC2 | DEC1 |
|---|---|---|---|---|---|---|---|
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

VOICE 1 POKE 54277,
VOICE 2 POKE 54284,
VOICE 3 POKE 54291,
Example:
POKE 54284,240 (128+64+32+16) produces a long attack but no decay for voice 2.

**3** Sustain/Release:– Prolongs note at a certain volume and releases it. As in 2, this is set separately for each voice, and both values are controlled by one register.

| SUS4 | SUS3 | SUS2 | SUS1 | REL4 | REL3 | REL2 | REL1 |
|---|---|---|---|---|---|---|---|
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

VOICE 1 POKE 54278,
VOICE 2 POKE 54285,
VOICE 3 POKE 54292,
Example:
POKE 54278,40 (32+8) gives a low sustain and high release for voice 1.

**4** Waveform:– One of four types:–

| | | **Code** |
|---|---|---|
| (i) | Triangle waveform | 17 |
| (ii) | Sawtooth waveform | 33 |
| (iii) | Pulse | 65 |
| (iv) | Noise | 129 |

Set separately for each voice
POKE 54276, code
POKE 54283, code
POKE 54290, code
Example:
POKE 54290,33 produces a sawtooth waveform for voice 3.

**5** High frequency/Low frequency:– To play a note on 64, you should POKE two values for each voice. The values to be POKEd are given in the following table.

Voice 1 POKE 54272, low frequency note value: POKE 54273, high frequency note value
Voice 2 POKE 54279, low frequency note value: POKE 54280, high frequency note value
Voice 3 POKE 54286 low frequency note value: POKE 54287, high frequency note value

Example:
POKE 54272,37: POKE 54273,17 plays middle C

## Music note values

The 64 note values to be POKEd into low and high frequency registers of SID chip.

| Note | Note-Octave | Hi Freq | Low Freq |
|---|---|---|---|
| 0 | C–0 | 1 | 18 |
| 1 | C#–0 | 1 | 35 |
| 2 | D–0 | 1 | 52 |
| 3 | D#–0 | 1 | 70 |
| 4 | E–0 | 1 | 90 |
| 5 | F–0 | 1 | 110 |
| 6 | F#–0 | 1 | 132 |
| 7 | G–0 | 1 | 155 |
| 8 | G#–0 | 1 | 179 |
| 9 | A–0 | 1 | 205 |
| 10 | A#–0 | 1 | 233 |
| 11 | B–0 | 2 | 6 |
| 12 | C–1 | 2 | 37 |
| 13 | C#–1 | 2 | 69 |
| 14 | D–1 | 2 | 104 |
| 15 | D#–1 | 2 | 140 |
| 16 | E–1 | 2 | 179 |
| 17 | F–1 | 2 | 220 |
| 18 | F#–1 | 3 | 8 |
| 19 | G–1 | 3 | 54 |
| 20 | G#–1 | 3 | 103 |
| 21 | A–1 | 3 | 155 |
| 22 | A#–1 | 3 | 210 |
| 23 | B–1 | 4 | 12 |
| 24 | C–2 | 4 | 73 |
| 25 | C#–2 | 4 | 139 |
| 26 | D–2 | 4 | 208 |
| 27 | D#–2 | 5 | 25 |
| 28 | E–2 | 5 | 103 |
| 29 | F–2 | 5 | 185 |
| 30 | F#–2 | 6 | 16 |
| 31 | G–2 | 6 | 108 |
| 32 | G#–2 | 6 | 206 |
| 33 | A–2 | 7 | 53 |
| 34 | A#–2 | 7 | 163 |
| 35 | B–2 | 8 | 23 |
| 36 | C–3 | 8 | 147 |
| 37 | C#–3 | 9 | 21 |
| 38 | D–3 | 9 | 159 |
| 39 | D#–3 | 10 | 60 |
| 40 | E–3 | 10 | 205 |

| Note | Note-Octave | Hi Freq | Low Freq |
|---|---|---|---|
| 41 | F–3 | 11 | 114 |
| 42 | F#–3 | 12 | 32 |
| 43 | G–3 | 12 | 216 |
| 44 | G#–3 | 13 | 156 |
| 45 | A–3 | 14 | 107 |
| 46 | A#–3 | 15 | 70 |
| 47 | B–3 | 16 | 47 |
| 48 | C–4 | 17 | 37 |
| 49 | C#–4 | 18 | 42 |
| 50 | D–4 | 19 | 63 |
| 51 | D#–4 | 20 | 100 |
| 52 | E–4 | 21 | 154 |
| 53 | F–4 | 22 | 227 |
| 54 | F#–4 | 24 | 63 |
| 55 | G–4 | 25 | 177 |
| 56 | G#–4 | 27 | 56 |
| 57 | A–4 | 28 | 214 |
| 58 | A#–4 | 30 | 141 |
| 59 | B–4 | 32 | 94 |
| 60 | C–5 | 34 | 75 |
| 61 | C#–5 | 36 | 85 |
| 62 | D–5 | 38 | 126 |
| 63 | D#–5 | 40 | 200 |
| 64 | E–5 | 43 | 52 |
| 65 | F–5 | 45 | 198 |
| 66 | F#–5 | 48 | 127 |
| 67 | G–5 | 51 | 97 |
| 68 | G#–5 | 54 | 111 |
| 69 | A–5 | 57 | 172 |
| 70 | A#–5 | 61 | 126 |
| 71 | B–5 | 64 | 188 |
| 72 | C–6 | 68 | 149 |
| 73 | C#–6 | 72 | 169 |
| 74 | D–6 | 76 | 252 |
| 75 | D#–6 | 81 | 161 |
| 76 | E–6 | 86 | 105 |
| 77 | F6 | 91 | 140 |
| 78 | F#–6 | 96 | 254 |
| 79 | G–6 | 102 | 194 |
| 80 | G#–6 | 108 | 223 |
| 81 | A–6 | 115 | 88 |
| 82 | A#–6 | 122 | 52 |
| 83 | B–6 | 129 | 120 |
| 84 | C–7 | 137 | 43 |
| 85 | C#–7 | 145 | 83 |
| 86 | D–7 | 153 | 247 |
| 87 | D#–7 | 163 | 31 |
| 88 | E–7 | 172 | 210 |
| 89 | F–7 | 183 | 25 |
| 90 | F#–7 | 193 | 252 |
| 91 | G–7 | 205 | 133 |
| 92 | G#–7 | 217 | 189 |
| 93 | A–7 | 230 | 176 |
| 94 | A#–7 | 244 | 103 |

## PERIPHERAL CONTROL COMMANDS

| Device | Device Number (dn) |
|---|---|
| Keyboard | 0 |
| Cassette recorder | 1 |
| Screen | 3 |
| Printer | 4 |
| Disc drive | 8 |

**CLOSE fn**
Closes the specified file that has been OPENed for either input or output. If file not closed at the end of writing, data may get lost.
Examples:
CLOSE #1 closes cassette file
CLOSE #4 closes printer channel
CLOSE #2-14 closes the specified disc channel
CLOSE #15 closes the error channel
Note: The error channel should be OPENed first and CLOSEd last.

**CMD dn**
Sends the output to the specified device instead of the screen.
Example:
OPEN 1,4:CMD4:LIST lists the entire program on the printer.

**COPY**
Makes a duplicate of a file or program on the same disc drive.
Format is:
PRINT #fn,"COPY0:NEWNAME=0:OLDNAME"
Example:
PRINT #5,"COPY0:TEST2=0:TEST1"

**GET#fn,v[$]**
Gets one character from the specified file at a time and assigns it to the specified variable. Characters read may include commas, colons, etc, whereas they cannot be read using INPUT # command.
Example:
GET#6, A$ gets a character from file 6 and assigns it to A$

**INITIALIZE**
Initializes the state of disc as if it has just been switched on.
Format is:
PRINT #fn, "INITIALIZE"
Example: PRINT #6, "INITIALIZE"

**INPUT #fn,V[$][,V[$]]**
Reads data from specified file and assigns it to the specified varaibles.
Example:
INPUT #1,A,B,C

**NEW**
Reformats an old disc, erasing all the files. Also used to format a new disc.
Format is:–
PRINT #fn ,"NEW0:name, Id"
Where Id is any two characters.

Example:
PRINT #15,"NEW0:FIRST,00"

**OPEN fn, dn, sn, "name"**
This command is used before any other peripheral control commands are used. This OPENs file fn to be used by INPUT#, GET#, CMD, CLOSE and PRINT# statements.
Sn = secondary number

| Sn | device | description |
|---|---|---|
| 0 | tape | read from file |
| 1 | tape | write to file |
| 2 | tape | write to file with an End-of-tape marker |
| 4 | printer | printer channel |
| 2-14 | disc drive | disc channels |
| 15 | disc | disc error channel |

**PRINT # fn, V[$][,V[$]]**
Writes the specified variable values to the specified file.
Examples:–
PRINT#5 , A ; CHR$(13);B;CHR$(13);C
writes each value to the file and inserts a RETURN in between to separate data. This is done on cassette file
PRINT#5, A, B$, C$, D
writes the specified values to the specified disc file.

**RENAME**
Renames a program or a file that is stored on disc.
Format is:
PRINT# fn, "RENAME0:NEWNAME=OLDNAME"
Example:
PRINT#6, "RENAME0:SORT=TOM"

**SCRATCH**
Erases the unwanted programs or files from disc.
Format is:
PRINT# fn, "SCRATCH0:name"
Example:
PRINT#6, "SCRATCH0:SORT"
deletes SORT from directory.

**VALIDATE**
Reorganises the files on disc so that the small blocks in between the files are joined to make a bigger block of storage.
Format is:
PRINT# fn, "VALIDATE"
Example:
PRINT #6, "VALIDATE"

**VERIFY "name", dn**
Checks the program in memory against the one on the specified device for match. If no match VERIFY ERROR is given.
Examples:
VERIFY "PROG1" checks with program stored on tape
VERIFY "PROG1",8 checks with program store on disc

**The Century Microguide to the Commodore 64 is a conveniently sized, clearly laid out, quick reference guide for the busy Commodore 64 owner. It comprehensively summarizes all the essential information needed by the Commodore 64 enthusiast and includes:**

- Special Keyboard Features
- Alphabetical Quick Reference
- BASIC commands
- Sound, Graphics and Colour
- Input/Output Instructions
- Numeric, Trigonometric and String Functions
- Arithmetic and Logic Operations
- Print and Plot Screens
- Error Handling
- Memory Maps
- System Variables
- Character Sets and Codes
- Disc Operating System Commands

**Each command is illustrated with simple examples to show how it is used in context and there are practical hints throughout the book.**

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