MEGA65

USER'S GUIDE

MEGA
MUSEUM OF ELECTRONIC GAMES & ART

MEGA65 TEAM

Assoc. Prof. Paul Gardner-Stephen
(highlander)
Founder
Software and virtual hardware architect
Spokesman and lead scientist

Martin Streit
(seriously)
Video and photo production
Tax and organization
Social media

Dan Sanderson
(dddaaannn)
Media and documentation
MEGA65.ROM

Dr. Edilbert Kirk
(Bit Shifter)
MEGA65.ROM
Manual and tools

Gábor Lénárt
(LGB)
Emulator

Farai Aschwanden
(Tayger)
Filehost and tools
Financial advisory

Falk Rehwagen
(bluewaysw)
GEOS

Robert Steffens
(kibo)
Network technology
Core bug hunting

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(deft)
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(lydon)
Release management
VHDL and platform enhancements

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(antti-brain)
Host hardware design and production

Dieter Penner
(doubleflash)
Host hardware support

Mirko H.
(sy2002)
Additional platforms and consulting

Gürçe Işıkyıldız
(gurce)
Tools and enhancements

Daniel England
(Mew Pokémon)
Additional code and tools

Hernán Di Pietro
(indiocolifa)
Additional emulation and tools

Roman Standzikowski
(FeralChild)
Open ROMs

Anton Schneider-Michallek
(adtbm)
Presentation and support

Reporting Errors and Omissions

This book is being continuously refined and improved upon by the MEGA65 community. The version of this edition is:

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commit 31db58e9f55ec6e4530e9f4c0288c64ed8830be2
date: Mon Mar 4 19:49:31 2024 +1030
```

We want this book to be the best that it possibly can. So if you see any errors, find anything that is missing, or would like more information, please report them using the MEGA65 User's Guide issue tracker:

https://github.com/mega65/mega65-user-guide/issues

You can also check there to see if anyone else has reported a similar problem, while you wait for this book to be updated.

Finally, you can always download the latest versions of our suite of books from these locations:

- https://mega65.org/mega65-book
- https://mega65.org/user-guide
- https://mega65.org/developer-guide
- https://mega65.org/basic65-ref
- https://mega65.org/chipset-ref
- https://mega65.org/docs

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CHAPTER 1

Introduction

- Welcome to the MEGA65!
- Other Books in this series
- Come Join Us!

WELCOME TO THE MEGA65!

Congratulations on your purchase of one of the most long-awaited computers in the history of computing! The MEGA65 is community designed, and based on the never-released Commodore® 65[1] computer; a computer designed in 1989 and intended for public release in 1990. Decades have passed, and we have endeavoured to invoke memories of an earlier time when computers were simple and friendly. They were not only simple to operate and understand, but friendly and approachable for new users.

These 1980s computers inspired many of their owners to pursue the exciting and rewarding technology careers they have today. Just imagine the exhilaration these early computing pioneers experienced, as they learned they could use their new computer to solve problems, write a letter, prepare taxes, invent new things, discover how the universe works, and perhaps even play an exciting game or two! We want to re-awaken that same level of excitement (which alas, is no longer found in modern computing), so we have created the **MEGA65**.

The MEGA65 team believes that owning a computer is like owning a home. You don't just use a home; you change things, big and small, to make it your own custom living space. After a while, when you settle in, you may decide to renovate or expand your home to make it more comfortable, or provide more utility. Think of the MEGA65 as your very own "computing home".

This guide will teach you how to do more than just hang pictures on a wall; it will show you how to build your dream home. While you read this user's guide, you will learn how to operate the MEGA65, write programs, add additional software, and extend hardware capabilities. What won't be immediately obvious is that along the journey, you will also learn about the history of computing as you explore the many facets of BASIC version 65 and operating system commands.

Computer graphics and music make computing more fun, and we designed the MEGA65 to be fun! In this user's guide, you will learn how to write programs using the MEGA65's built-in **graphics** and **sound** capabilities. But you don't need to be a programmer to have fun with the MEGA65. Because the MEGA65 includes a complete Commodore® 64™[2], it can also run thousands of existing games, utilities, and business software packages, as well as new programs being written today by Commodore computer enthusiasts. Excitement for the MEGA65 will grow as we all witness the programming marvels our MEGA65 community create, as they (and you!) discover and master the powerful capabilities of this modern Commodore computer recreation. Together, we can build a new "homebrew" community, teeming with software and projects that push the MEGA65's capabilities far beyond what anyone thought would be possible.

We welcome you on this journey! Thank you for becoming a part of the MEGA65 community of users, programmers, and enthusiasts!

[1] Commodore is a trademark of C= Holdings

[2] Commodore 64 is a trademark of C= Holdings

OTHER BOOKS IN THIS SERIES

This book is one of several within the MEGA65 documentation suite. The series includes:

- **The MEGA65 User's Guide**
  Provides an introduction to the MEGA65, and a condensed BASIC 65 command reference
- **The MEGA65 BASIC 65 Reference**
  Comprehensive documentation of all BASIC 65 commands, functions and operators
- **The MEGA65 Chipset Reference**
  Detailed documentation about the MEGA65 and C65's custom chips
- **The MEGA65 Developer's Guide**
  Information for developers who wish to write programs for the MEGA65
- **The MEGA65 Complete Compendium**
  (Also known as **The MEGA65 Book**)
  All volumes in a single huge PDF for easy searching. 1200 pages and growing!

COME JOIN US!

Get involved, learn more about your MEGA65, and join us online at:

- https://mega65.org/chat
- https://mega65.org/forum

CHAPTER 2

Setup

- Unpacking and Connecting the MEGA65
- Rear Connections
- Side Connections
- MEGA65 Screen and Peripherals
- Optional Connections
- Switching the MEGA65 on for the First Time
- The Intro Disk
- The Cursor

UNPACKING AND CONNECTING THE MEGA65

It is time to set up your MEGA65 home computer! The box contains the following:

- MEGA65 computer
- Power supply (black box with socket for mains supply)
- This book, the MEGA65 User's Guide
- Your personal registration code, on a piece of paper (possibly tucked into the User's Guide)

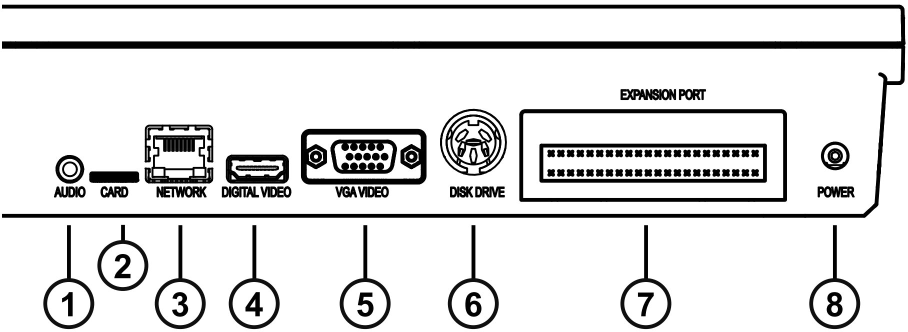
In addition, to be able to use your MEGA65 computer you will need:

- A television or computer monitor with a VGA or digital video input, capable of displaying an image at 480p (720x480) at 60Hz or 576p (720x576) at 50Hz
- An appropriate video cable for your display, either VGA or digital video

You may also like to use the following to get the most out of your MEGA65:

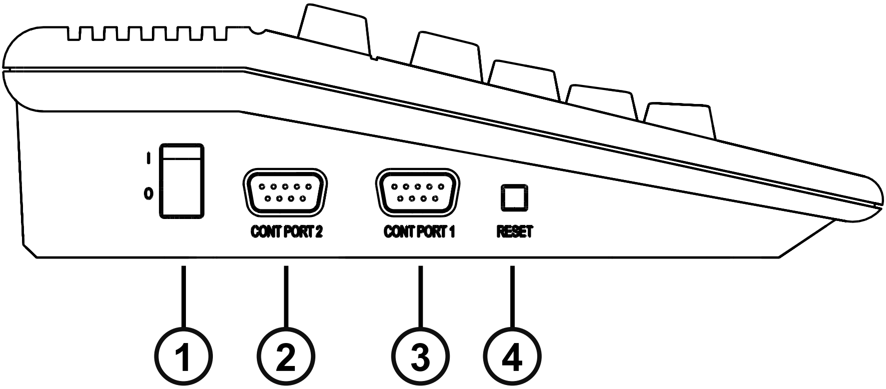
- A digital video display with built-in audio, or powered speakers and an appropriate audio cable with 3.5mm audio jack connector
- A microSD card, type SDHC, between 4GB and 32GB in size
- An RJ45 Ethernet cable and a network router or switch
- A joystick or gamepad compatible with Commodore computers, with a nine-pin (DE-9) connector
- A Commodore 1351 mouse, an Amiga mouse, or a modern replacement such as a mouSTer USB mouse adapter

REAR CONNECTIONS



1	3.5mm Audio Jack
2	External microSD Card Slot
3	Network LAN Port
4	Digital Video Connector (including sound)
5	VGA Video Connector
6	IEC Serial Bus Connector for Disk Drives and Printers
7	Cartridge Expansion Port
8	Power Supply Socket

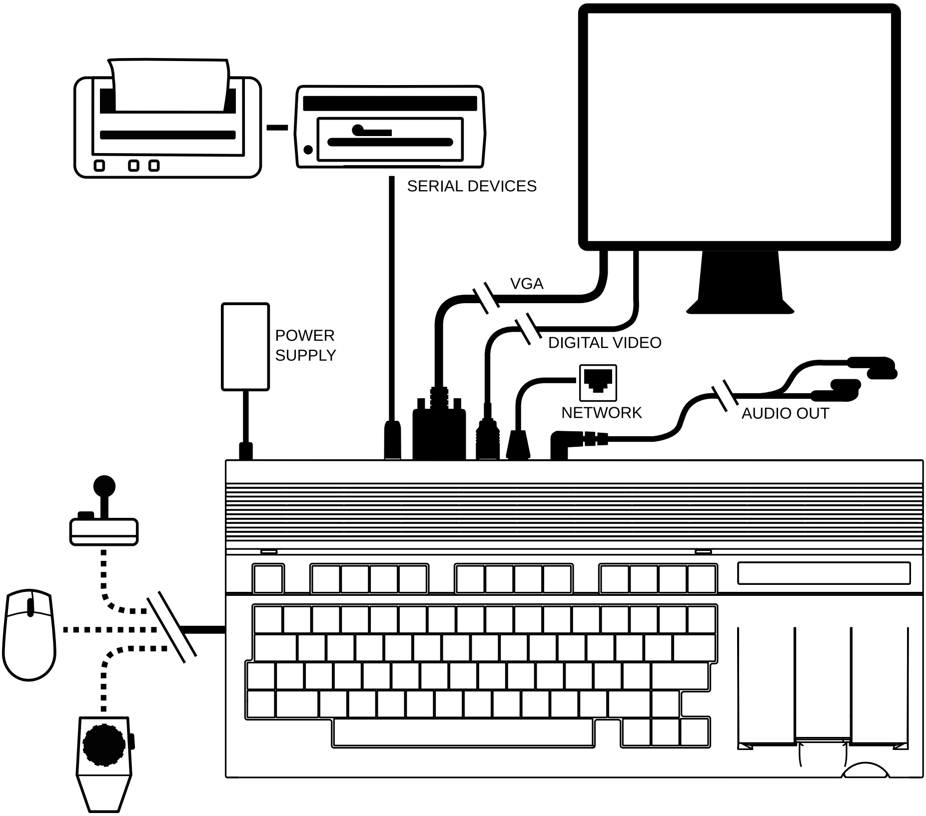
SIDE CONNECTIONS



1	Power Switch
2	Controller Port 2
3	Controller Port 1
4	Reset Button

Various peripherals can be connected to Controller Ports 1 and 2 such as joysticks, paddles or mouse devices.

MEGA65 SCREEN AND PERIPHERALS



To connect your MEGA65 to a display:

1. Connect the power supply to the power supply socket of the MEGA65.
2. If you have a VGA monitor and a VGA cable, connect one end to the VGA port of the MEGA65 and the other end into your VGA monitor.
3. If you have a TV or monitor with a compatible Digital Video connector,[1] connect one end of your cable to the Digital Video port of the MEGA65, and the other into the Digital Video port of your monitor. If you own a monitor with a DVI socket, you can use a Digital Video to DVI adapter.

[1]The Digital Video connector type has a recognizable four-letter commercial name, but the MEGA65 project has not paid the licensing fees to refer to it by this name. This *User's Guide* refers to this as the "Digital Video" connector.

OPTIONAL CONNECTIONS

1. The MEGA65 includes an internal 3.5" floppy disk drive. You can also connect older Commodore® IEC serial floppy drives to the MEGA65, such as the Commodore 1541, 1571 or 1581. To use these drives, connect one end of an IEC cable to the Commodore floppy disk drive and the other end to the Disk Drive socket of the MEGA65. You can also connect an SD2IEC device or a Pi1541 device. With most devices, you can daisy-chain additional floppy disk drives or Commodore compatible printers.
2. You can connect your MEGA65 to an Ethernet network using a standard Ethernet cable.
3. For enjoying audio from your MEGA65, you can connect a 3.5mm audio jack cable to an audio amplifier or speaker system. If your system has RCA connectors you will need a 3.5mm audio jack to twin RCA adapter cable. The MEGA65 also has a built-in amplifier to allow the use of headphones.
4. A microSD card, type SDHC between 4GB and 32GB, can be inserted into the external microSD card slot at the rear of the MEGA65. For more information on using the microSD card slot, see "Introducing SD Cards" on page 37.
5. Underneath the MEGA65, a small door provides access to the internal SD card and two connectors for future hardware expansion.

INSTALLING THE REAL-TIME CLOCK BATTERY

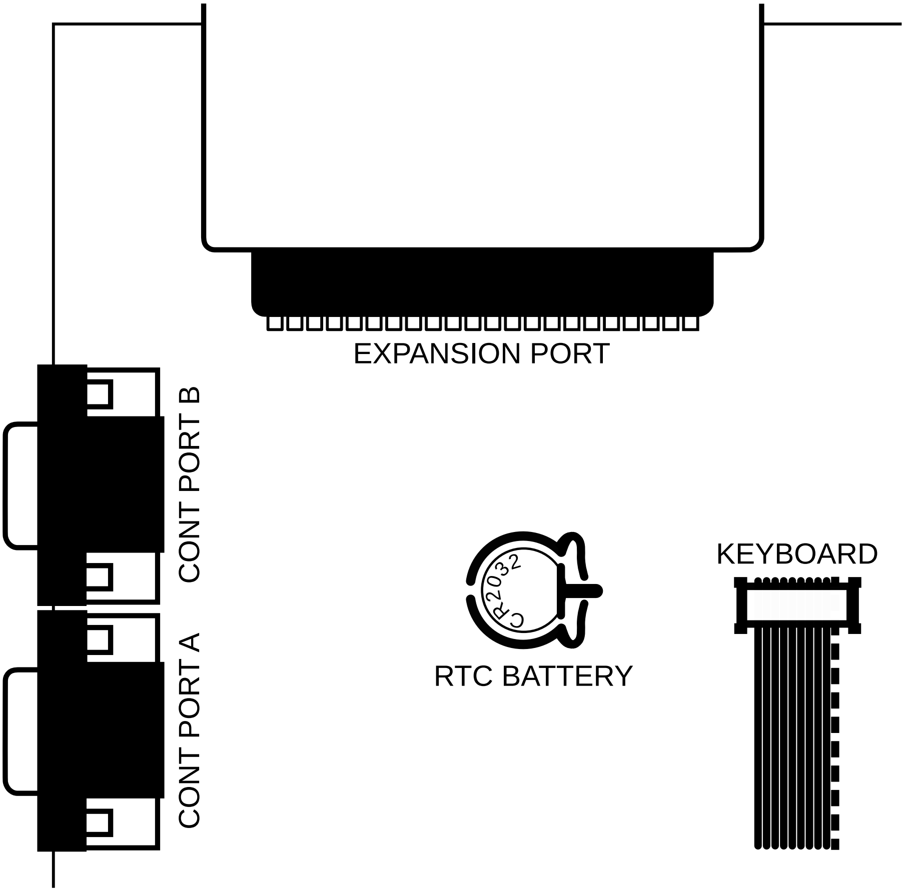
The MEGA65 includes a Real-Time Clock, which is used to display the time and date on the startup screen, to add timestamps to files that the MEGA65 writes to your SD cards, and to provide the **DT$** and **TI$** BASIC variables for use in programs. This clock uses a CR2032 coin-cell battery to keep the time when the MEGA65 is disconnected from power for long periods of time. The MEGA65 does not include a battery in order to avoid issues related to shipping batteries internationally.[2]

The RTC battery is optional. The MEGA65 can keep the RTC running without a battery, even when the computer is disconnected from power, for multiple days at a time. Installing a battery allows the computer to remember the time for much longer periods. (You can always set the clock again later.)

To install the battery, use a Phillips-head screwdriver to open the case, exposing the motherboard. The case is held together with three screws, all of which are along the bottom of the front side of the case. Once the screws have been removed, carefully lift the top half of the case. Note the orientation of the keyboard connector, then disconnect it.

[2] Early models of MEGA65 with the "R3A" board revision (made in the year 2022) use a battery of type CR1220 for the Real-Time Clock, and the battery is required for the RTC to function. Revision "R6" (made in 2024) uses a battery of type CR2032, and the battery is optional for regular use.

The battery is located between the controller ports and the keyboard connector.



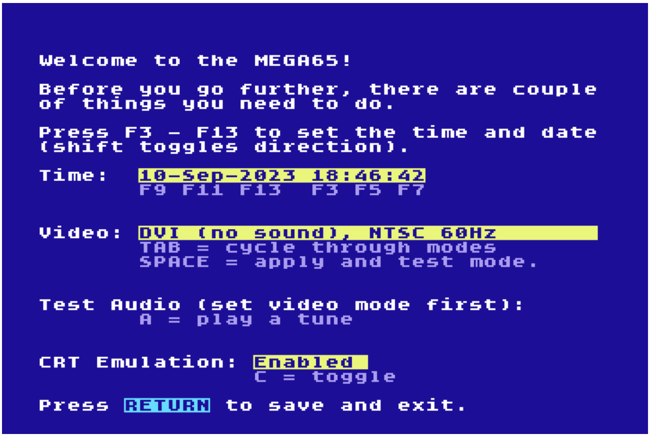
If you are removing an existing battery, push the battery release lever on the bottom (flat-sided) side of the battery socket away from the battery to remove it. Insert the new battery with the side labelled **+** facing up, and press it into place.

Once you have re-assembled your MEGA65, you can set the time in the Configuration Utility. For more information on how to set the Real-Time Clock, refer to the Configuration Utility section on page 31.

SWITCHING THE MEGA65 ON FOR THE FIRST TIME

Switch the MEGA65 on using the power switch on the left-hand side of the computer.

When you switch your MEGA65 on for the first time, it displays the initial configuration ("on-boarding") screen. You can use this screen to set the time and date on the Real-Time Clock, change the video display mode, and test the audio. All of these settings can be changed later.

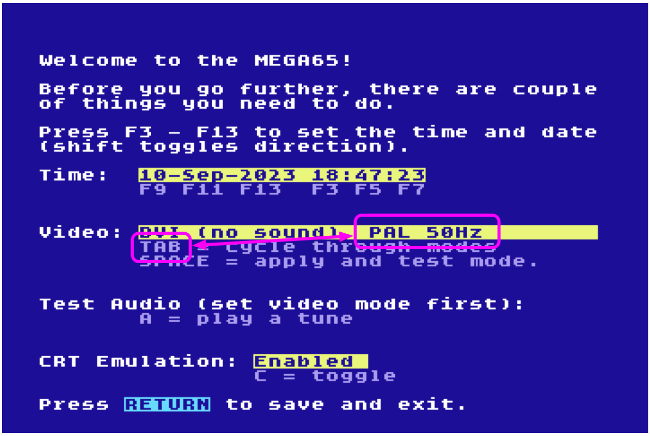


For video display modes, you can select between PAL or NTSC emulation, and you can select whether your Digital Video display supports sound. If you are using the VGA video output, the Digital Video sound mode has no effect.

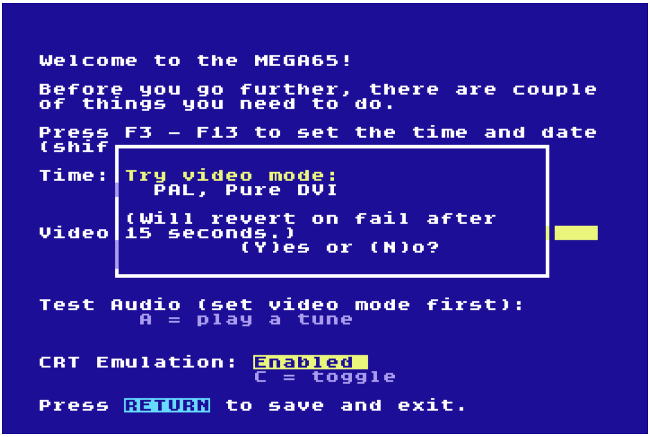
NOTE: A DVI display that does not support sound will not work with the "enhanced" sound mode. With such a display, you must select a video mode with "no sound," and connect a speaker to the 3.5 mm audio jack.

PAL and NTSC are analog video signal formats that affect the resolution and vertical sync speed of the video output, even when using a modern digital display. Your display may support either mode, or it may only support one or the other. You can use this screen to test the modes with your display.

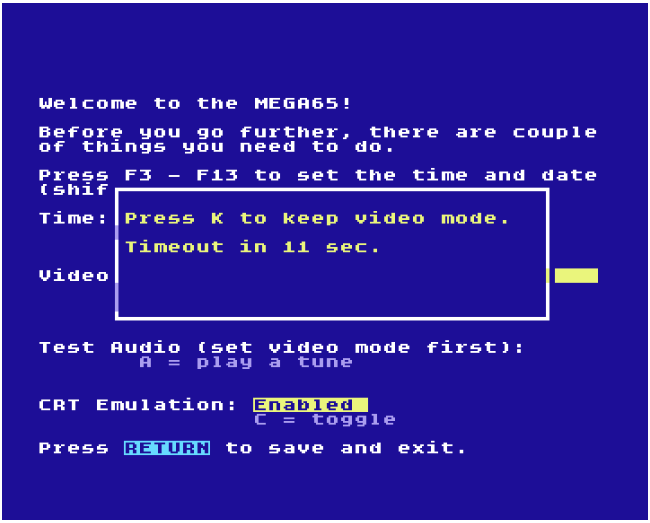
Select and test your video configuration. For example, press TAB to switch to the **PAL 50HZ** mode.



Press **SPACE** followed by **Y** to test the new video mode.



Press **K** to keep the new video mode.



Take this opportunity to test your sound set-up. Press **A** to play a sound.

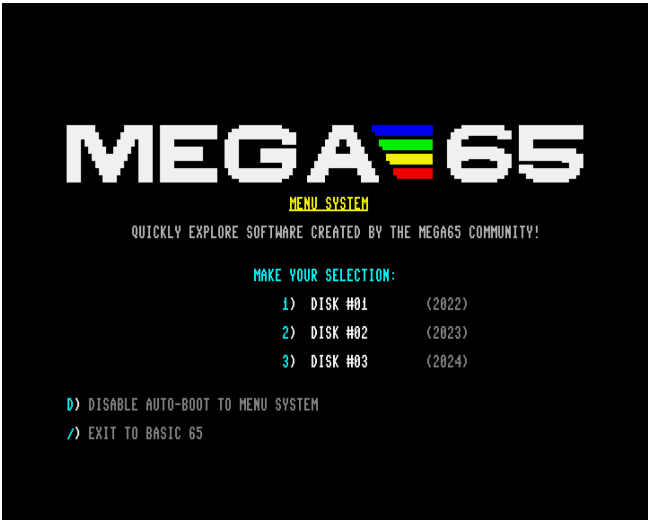
The “CRT emulation” option is a fun choice when using a modern flat panel display. It adds vertical gaps between pixels to simulate the CRT raster line. Try it to see if you like it: press the **C** key to toggle it on and off.

Finally, press **RETURN** to complete the configuration.

For more information about configuring your MEGA65, see chapter 4 on page 31.

THE INTRO DISK

After completing the on-boarding configuration, your MEGA65 starts the Intro Disk menu. The Intro Disk is a collection of software made by the MEGA65 community that demonstrates some of the capabilities of the computer. Take some time to browse the menus and try some of the demos. After each demo, press the reset button on the left-hand side of the computer to return to the Intro Disk menu.



By default, the Intro Disk menu opens each time you switch on the computer. Once you are more familiar with the MEGA65, you may wish to disable this. Press **D** at the Intro Disk menu to disable its auto-boot feature.

Press **/** (forward slash) to exit the Intro Disk menu and access BASIC 65. With the Intro Disk auto-boot feature disabled, the MEGA65 goes directly to BASIC 65 when you switch it on.

THE CURSOR

The flashing square underneath the READY prompt is called the cursor. The cursor indicates that the computer is ready to accept input. Pressing keys on the keyboard will print their respective characters onto the screen. The characters will be printed at the current cursor position, and the cursor will advance to the next position after every key press.

Here you can type commands that can do things such as loading a program. You can also start entering program code!

CHAPTER 3

Getting Started

- Keyboard
- The Screen Editor
- Editor Functionality
- The Freezer Menu
- Running Commodore 64 Software

KEYBOARD

Now that everything is connected, it's time to get familiar with the MEGA65 keyboard.

You may notice that the keyboard is a little different to the keyboards used on computers today. While most keys will be in familiar positions, there are some specialised keys, and some with special graphic symbols marked on the front.

The graphic symbols are typable in some display modes, similar to letters, numbers, and punctuation. The complete set of characters is known as the *PETSCII character set*.

SPECIAL KEYS

RETURN

Pressing RETURN enters the information you have typed into the MEGA65's memory. The computer will either act on a command, store some information, or display an error message if you made a mistake.

SHIFT

The two SHIFT keys are located on the left and the right. They work very much like the Shift key on a regular keyboard. They also perform some special functions as well.

In upper case mode, holding down SHIFT and pressing any key with two graphic symbols on the front produces the right-hand symbol on that key. For example, SHIFT and J prints the character.

In lower case mode, pressing SHIFT and a letter key prints the upper case letter on that key.

Finally, holding SHIFT down and pressing a Function key accesses the function shown on the front of that key. For example: SHIFT and F1 activates F2.

SHIFT LOCK

In addition to SHIFT is SHIFT LOCK. Press this key to lock down the Shift function. Now any key you press while SHIFT LOCK is illuminated prints the character to the screen as if you were holding down SHIFT. This includes special graphic characters.

CTRL

CTRL is the Control key. Holding down CTRL and pressing another key allows you to perform Control functions. For example, holding down CTRL and one of the number keys (from 1 to 8) allows you to change text colours. The colour that is printed at the top row on the front of the number key will be used. Holding down CTRL and pressing 9 or 0 switches reverse-text mode on and off.

There are some examples of this on page 21, and all of the Control functions are listed on page 267.

If a program is being **LIST**ed to the screen, holding down CTRL slows down the display of each line. You can read more about the **LIST** command on page 178.

Holding CTRL and pressing * enters the Matrix Mode Debugger (refer to the **MEGA65 Book** for more details).

RUN STOP

Normally, pressing RUN STOP stops the execution of a program. Holding SHIFT while pressing RUN STOP **RUN**s the first program from disk.

Some programs override the RUN STOP key and cannot be stopped in this way.

You can boot your MEGA65 into the **Machine Code Monitor** by holding down RUN STOP and pressing reset on the left-hand side of the computer.

RESTORE

The computer screen can be restored to a clean state without clearing the memory by holding down RUN STOP and pressing RESTORE. This combination also resets operating system vectors and re-initialises the screen editor, which makes it a handy combination if the computer has become a little confused.

Some programs override the RUN STOP + RESTORE key combination and cannot be reset in this way.

You can also enter the **Freezer** by pressing and holding RESTORE for one second, then releasing the key. You can read more about the Freezer on page 26.

THE CURSOR KEYS

At the bottom right-hand side of the keyboard are the cursor keys. These four directional keys allow you move the cursor to any position for on-screen editing.

The cursor moves in the direction indicated on the keys: ← ↑ → ↓.

You don't have to keep pressing a cursor key over and over. If you need to move the cursor a long way, you can keep the key pressed down. When you are finished, simply release the key.

ARROW KEYS

These keys are different to the cursor keys! They are ← (next to 1), and ↑ (next to RESTORE). Both arrow keys are used in various BASIC functions and escape sequences.

For example, ← can be used as a shortcut for **SAVE**, and ↑ is used to raise a number to a power (which is the same as multiplying a number by itself a specified number of times).

You can read more about the available escape sequences on page 270.

These two PETSCII specific keys will always be shown in MEGA65 literature with a white background.

It is also possible to move the cursor up by using SHIFT and ↓, and left by using SHIFT and →. This owes to the MEGA65's Commodore 64 heritage, which only had two cursor keys.

INSerT/DELete

The INST DEL key, the rightmost key of the top row, is the INSERT / DELETE key. When you press INST DEL, the character to the left is deleted, and all characters to the right are shifted one position to the left.

To insert a character, hold SHIFT and press INST DEL. All the characters to the right of the cursor are shifted to the right. This allows you to type a letter, number or any other character at the newly inserted space.

CLeaR/HOME

The CLR HOME is the CLEAR / HOME key. Pressing CLR HOME places the cursor at the top left-most position of the screen.

Holding down SHIFT and pressing CLR HOME clears the entire screen *and* places the cursor at the top left-most position of the screen.

If you press CLR HOME accidentally, you can return the cursor to its prior position by pressing ESC then CLR HOME.

MEGA KEY

or the MEGA key provides a number of different functions and can be used to launch special utilities.

Holding **SHIFT** and pressing switches between lower and uppercase character modes.

Holding and pressing any key with two graphic symbols on the front prints the left-most graphic symbol to the screen. For example, and **D** prints the symbol.

Holding and pressing any key that shows a single graphic symbol on the front prints that graphic symbol to the screen.

Holding and pressing a number key switches to a secondary colour, i.e., the colour that is printed at the bottom row on the front of the number key.

Holding and pressing **TAB** enters the Matrix Mode Debugger (refer to the **MEGA65 Book** for more details).

Switching on the MEGA65 or pressing the reset button on the left-hand side while holding down switches the MEGA65 into GO64 mode.

NO SCROLL

If a program is being **LIST**ed to the screen, pressing **NO SCROLL** pauses the screen output. Press any key to un-pause.

This feature is not available in GO64 mode.

FUNCTION KEYS

There are seven Function keys available for use by software applications. **F1** **F3** **F5** **F7** **F9** **F11** and **F13** can be used to perform special functions.

Hold **SHIFT** to access **F2** through to **F14** as shown on the front of each Function key. Only Function keys **F1** to **F8** are available in GO64 mode.

HELP

HELP can be used by software and also acts as **F15** / **F16**.

ALT

Holding ALT down while pressing other keys can be used by software to perform specific functions. This feature is not available in GO64 mode.

Holding ALT down while switching the MEGA65 on activates the Utility Menu. You can format an SD card, or enter the MEGA65 Configuration Utility to select the default video mode and change other settings, or test your keyboard.

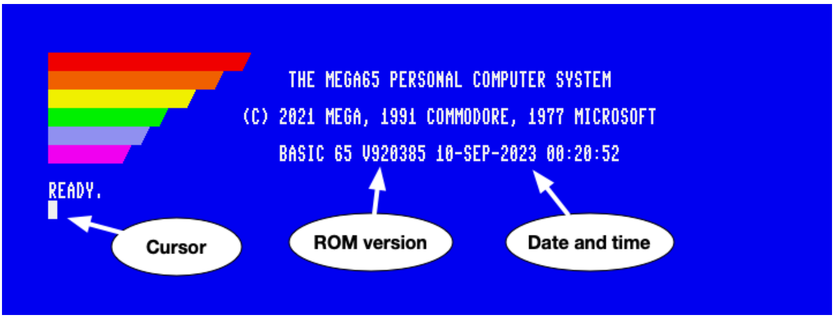
CAPS LOCK

CAPS LOCK works similarly to SHIFT LOCK in C65 and MEGA65-modes, but only modifies the letter keys.

When the MEGA65 is set to run at a reduced processor speed, such as in GO64 mode, you can hold down CAPS LOCK to run the processor at full speed temporarily. This is useful in GO64 mode for things such as speeding up loading from the internal disk drive or SD card, or to greatly speed up the de-packing process after a program is run. MEGA65 mode runs at maximum speed by default.

THE SCREEN EDITOR

When you switch on your MEGA65 or reset it, the following screen will appear:[1]



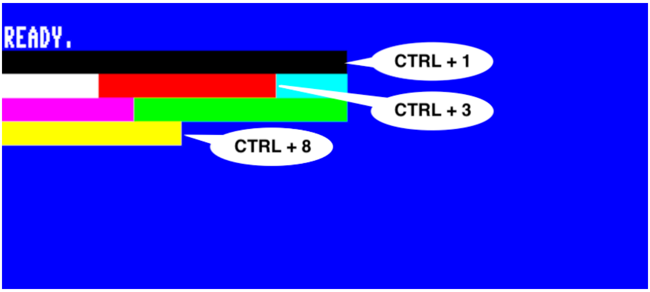
The colour bars in the top left-hand side of the screen can be used as a guide to help calibrate the colours of your display. The screen also displays the name of the system, the copyright notice, and the ROM version. The displayed date and time are taken from the internal RTC (Real-Time Clock) at the time the computer was powered on. You can set the date and time in the Configuration Utility.

Finally, you will see the READY prompt and the flashing cursor.

[1] This assumes you have disabled the Intro Disk menu. If the Intro Disk menu is running, press "/" (forward slash) to exit to this screen.

You can begin typing keys on the keyboard and the characters will be printed at the cursor position. The cursor itself will advance after each key press.

You can also produce reverse text or colour bars by holding down CTRL and pressing 9, or R. This enters reverse text mode. When this is enabled, you can press and hold the SPACE bar. While doing so, a white bar will be drawn across the screen. You can change the current colour by holding CTRL down and pressing a number key (from 1 to 8). For example, if you press and hold CTRL down and press 1, the colour will change to black. Now, when you hold down the SPACE bar, a black bar will be drawn. If you continue to change the colour and press the SPACE bar, you will get an effect similar to the following image:



You can disable reverse text mode by holding CTRL and pressing 0.

A further eight colours can be selected by holding down and pressing a key from 1 to 8.

The colour that is printed at the bottom row on the front of the number key will be used. For example, if you held down while pressing 4, dark grey will be used. For access to an additional 16 colours of the alternate/rainbow palette, refer to the CTRL + A shortcut described on page 267.

NOTE:

- **Quote Mode**: If you were to press " to open a string, and then try to change colours, reverse text, move the cursor keys, or use the CLR HOME key, instead of these actions instantly occurring, funny PETSCII symbols will appear instead. This is due to a BASIC facility called *quote mode*, which allows you to encode such actions into a string so that they can be executed at a later time (for example, via a **PRINT** statement within your programs). To end *quote mode*, simply type another " to mark the end of your string.

- **Insert Mode**: A similar facility is called *insert mode*, where for the number of times you press SHIFT + INST DEL to insert a few spaces, the same number of keypresses that follow it will abide by the same principles of *quote mode*.
- You can forcefully exit either of these modes by pressing ESC, O.

You can create fun pictures just by using these colours and letters. Here's an example of what a 4th year student drew:

What will you draw?

Functions

Functions using CTRL are called **Control Codes**. Functions using MEGA are called **Mega Codes**. There are also functions that are called by using SHIFT, which are called **Shifted Codes**.

Lastly, ESC enables the use of **Escape Sequences**.

You can read about all of these functions in detail on page 267.

ESC Sequences

Escape sequences are performed a little differently than a Control function or a Shift function. Instead of holding the modifier key down, an Escape sequence is performed by pressing ESC and releasing it, followed by pressing the desired key.

For example: to switch between 80 column mode and 40 column mode, press and release ESC, then press X.

There are more text modes available. You can create flashing text by holding CTRL down and pressing O. Any characters you type in will flash. Turn flash mode off by pressing ESC, then O.

EDITOR FUNCTIONALITY

The MEGA65 screen editor supports several ways to quickly move the cursor around the screen to help you to be more productive.

For example, press CLR HOME to go to the home position on the screen. Hold CTRL down and press W several times. This is the **Word Advance function**, which jumps your cursor to the next word, or printable character.

You can set custom tab positions on the screen for your convenience. Press CLR HOME and then → to move the cursor to the fourth column. Hold down CTRL and press X to set a tab. Move another 16 positions to the right, and press CTRL and X again to set a second tab.

Press CLR HOME to go back to the home position. Hold CTRL down and press I. This is the **Forward Tab function**. Your cursor will tab to the fourth position. Press CTRL and I again. Your cursor will move to position 8. By default, every 8th position is already set as a tabbed position. So the 4th and 20th positions have been added to the existing tab positions. You can continue to press CTRL and I to advance to the 16th and 20th positions.

CREATING A WINDOW

You can set a window on the MEGA65 working screen. Move your cursor to the beginning of the "BASIC 65" text. Press ESC, then press T. Move the cursor 10 lines down and 15 to the right.

Press ESC, then B. Anything you type will be contained within this window.

For example, if you were to type `LIST` to list out a program, the listing will be confined to the window region you have specified:

To escape from the window back to the full screen, press CLR HOME twice.

ADDITIONAL ASCII CHARACTERS

You may have noticed a few ASCII characters on the MEGA65 keyboard that aren't traditionally a part of the PETSCII character set. In order to make use of these from within BASIC:

- Type either `FONT A` or `FONT B`.
- Press MEGA + SHIFT to switch to lowercase.

You will now be able to type those additional ASCII characters via the keyboard. To revert back to the original PETSCII character set, type `FONT C`.

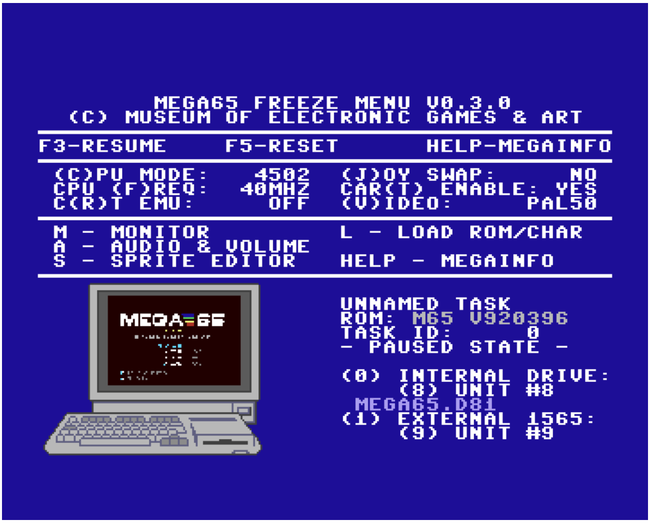
UPPERCASE AND LOWERCASE

MEGA + SHIFT switches between uppercase and lowercase text for the entire display. This works even during program execution, so you can adjust it if a program is in the wrong mode.

THE FREEZER MENU

The MEGA65 spends most of its time behaving as a Commodore 65 computer would, either running a program or awaiting instructions in the BASIC environment. Your MEGA65 has additional features that were not part of the original C65 design. You can access many of these features from the Freezer menu.

To open the Freezer menu, hold the **RESTORE** key for one second, then release it. The MEGA65 will pause whatever it is doing, flicker the border colour, then open the Freezer menu. Whatever program was running remains in memory and can be resumed by pressing the **F3** key. You can also abandon the running program and reset the MEGA65 by pressing **F5**.



One feature to remember when playing games is the "(J)OY SWAP." This causes the two joystick ports to trade numbers. If you have a joystick in port 2 and you start a game that expects a joystick in port 1, instead of disconnecting and reconnecting the joystick, open the Freezer menu, press **J** to swap the port numbers, then resume your game.

This is called the "Freezer" menu because the state of the MEGA65 remains frozen while using it. The Freezer menu can store multiple freeze states, and you can switch between them. To save the current state, navigate to an unused *freeze slot* using the cursor-right key, then press **F7**. When the border stops blinking, the state is saved. To restore a state, navigate to the freeze slot, then press **F3** to resume operation.

The Freezer menu has several built-in options and features. For more information about the MEGA65 Information Utility ("MEGAINFO"), see "Determining the Versions of Things" on page 48. For more information about mounting disks and disk images, see chapter 6 on page 63.

RUNNING COMMODORE 64 SOFTWARE

The MEGA65 is capable of running Commodore 64 software. There are two ways to do this: the built-in GO64 mode, and the *C64 for MEGA65* FPGA core.

GO64 MODE

The original Commodore 65 was designed to be capable of running some Commodore 64 software. The MEGA65 supports this feature, known as "GO64 mode."

NOTE: Due to how Commodore designed this feature, not all C64 software is compatible with this mode. Unlike the similar feature of the Commodore 128, the Commodore 65 uses a different CPU, and minor differences are known to cause compatibility issues with some software titles.

There are three ways to switch the MEGA65 into GO64 mode:

- Switch off the computer, hold the and switch it back on.
- From the MEGA65 `READY` prompt, enter this command: `GO64` Enter `YES` when prompted.
- Switch off the computer, connect a Commodore 64 cartridge to the expansion port, then switch the computer on.

GO64 mode is actually just a temporary re-configuration of the MEGA65. All of the MEGA65's features are still present, including the Freezer menu for mounting D81 disk images.

Much Commodore 64 software can be found on the Internet in the form of D64 disk images. The MEGA65 only supports D81 disk images via the SD card and Freezer menu. You can use a peripheral such as the SD2IEC with the MEGA65's IEC port to use D64 disk images. Be sure to obtain an SD2IEC with an independent power supply, and not one that depends on a Commodore 64 tape connector.[2]

THE "C64 FOR MEGA65" FPGA CORE

The *C64 for MEGA65* FPGA core by MJoergen and sy2002 re-creates the original Commodore 64 computer on MEGA65 hardware with a high degree of accuracy. It does so by completely replacing the MEGA65 core with one that implements the Commodore 64 chipset, including its CPU. MEGA65 features such as the Freezer menu are not available when running the C64 core. Instead, the core provides its own menu for mounting D64 disk images and other features. Press the HELP key with the core running to access this menu.

For information about installing FPGA cores, see chapter 5 on page 47. To download the *C64 for MEGA65* core and read important installation instructions, see: `https://github.com/MJoergen/C64MEGA65`

[2]For more information on SD2IEC devices, see: `https://www.c64-wiki.com/wiki/SD2IEC`

CHAPTER 4

Configuring Your MEGA65

- Configuring Your MEGA65
- The Configuration Utility
- Introducing SD Cards
- Preparing a New SD Card

CONFIGURING YOUR MEGA65

This chapter describes how to configure your MEGA65.

Configuration data is stored on the SD card, so this chapter also describes how to prepare a new SD card. Your MEGA65 comes with an SD card pre-installed. If you configure your MEGA65 using the pre-installed SD card then later install a new SD or microSD card, you will need to set your configuration settings again.

This chapter also introduces the MEGA65 Filehost website, which you can use to download games, apps, tools, and system updates for your computer.

THE CONFIGURATION UTILITY

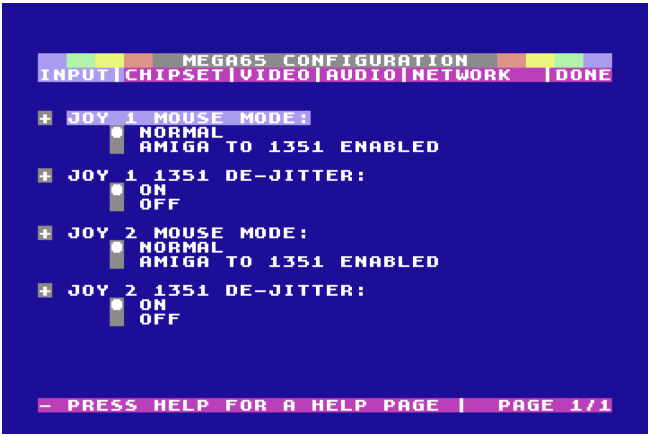
You can configure your MEGA65 using the Configuration Utility. This includes the settings shown when you switched on the machine for the first time, and many others.

To access the Configuration Utility, switch off the MEGA65, hold the ALT key and switch it back on. The Utility menu appears with several options. Press 1 to start the Configuration Utility.

The Configuration Utility includes several pages of settings, which you can navigate using the keyboard or a mouse connected to port 1. Use ← and → to navigate between pages, and ↑ and ↓ to select items on the page. Press RETURN or SPACE to toggle a setting or change a value.

INPUT

The **Input** page configures the mouse settings for the two peripheral ports.



The MEGA65 supports the Commodore 1351 mouse, the Commodore Amiga mouse, or modern equivalents such as a USB mouse connected with a mouSTer adapter. The port must be set to the correct mouse type, where **normal** refers to the 1351 mouse. If an Amiga mouse is connected while the port is in the **normal** mode, it may interfere with the behavior of the keyboard.

The **1351 De-jitter** setting adjusts the sensitivity in Commodore 1351 mouse mode to avoid jitter in the mouse pointer. It is recommended to leave this set to **on** when using a 1351 mouse in **normal** mode.

CHIPSET

The **Chipset** page configures several features, including the Real-Time Clock.

To set the Real-Time Clock, select the time or date field, type the complete value, then press RETURN. The clock setting takes effect as soon as you press RETURN, and does not take effect unless you press RETURN. Note that all other settings are not saved until the end. Only the RTC is updated immediately.

The **DMAGIC revision** field controls the behavior of the DMA controller. In most cases, you want the newer **F018B** setting. The **F018** setting is for backwards compatibility when running the C65 versions of the ROM, and is not always required.

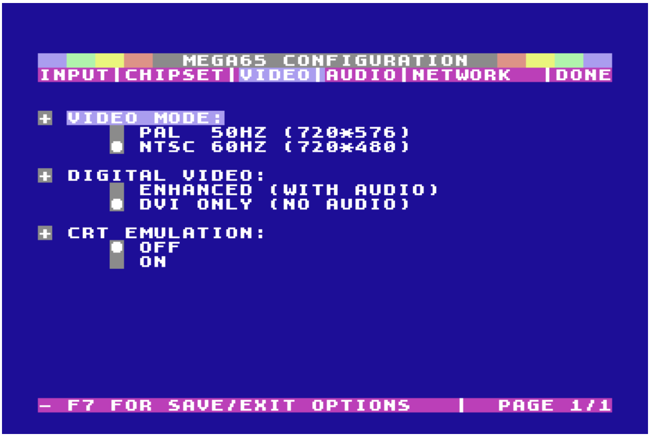
The **F011 disk controller** field determines whether the MEGA65 looks for a boot disk on the SD card or in the physical 3.5″ floppy drive when the computer is switched on. When set to **SDCARD disk image,** the MEGA65 uses the D81 virtual disk image named in the **default disk image** field as the boot disk. When you first get your MEGA65, this is set to the Intro Disk, named `MEGA65.D81`. You can change this to a different disk. To disable auto-mounting, change the disk name to a filename that does not exist, or rename the `MEGA65.D81` file on the SD card. (Leaving the setting empty will default to `MEGA65.D81`.)

If **F011 disk controller** is set to **3.5″ floppy drive,** the boot process will pause just before the READY. prompt to check if a boot disk is inserted in the drive. If you do not use a physical boot disk, you may wish to leave this set to **SDCARD disk image** for a faster boot process.

Long FN support refers to long filename support in the MEGA65 SD card file browser features. Leave this enabled unless there is an issue with reading files with filenames longer than 11 characters.

VIDEO

The **Video** page configures video settings. These are the same settings from the on-boarding configuration, including the PAL or NTSC video mode, Digital Video sound, and CRT emulation.



Video mode selects between the PAL compatibility mode and the NTSC compatibility mode. You can also change this while running programs using the Freezer menu.

The **Digital Video** setting enables or disables the combined video and audio signal over the Digital Video port. If your Digital Video display has built-in speakers, enable this setting (**Enhanced (with audio)**) to use them. Some DVI displays without built-in speakers require that this is disabled.

CRT emulation is an optional setting that makes the picture look more like that of a vintage Cathode Ray Tube display when using a modern flat-panel display.

AUDIO

The **Audio** page configures the MEGA65 sound system. In most cases, you can leave these at their default settings.

Audio output can be configured to use full stereo, or to send a monoaural signal to both speakers. When in stereo mode, various audio devices in the MEGA65 can be panned to the left or right using the audio mixer in the Freezer menu. The default settings pan the four SID chips slightly to the left and right.

SID generation selects between the audio emulation of the two models of SID sound chips: the original 6581 used in some Commodore 64s, and the newer 8580 used in later Commodore 64s and 128s. Some Commodore 64 games took advantage of flaws in the 6581 that were fixed in the 8580, and so sound better with the older generation.

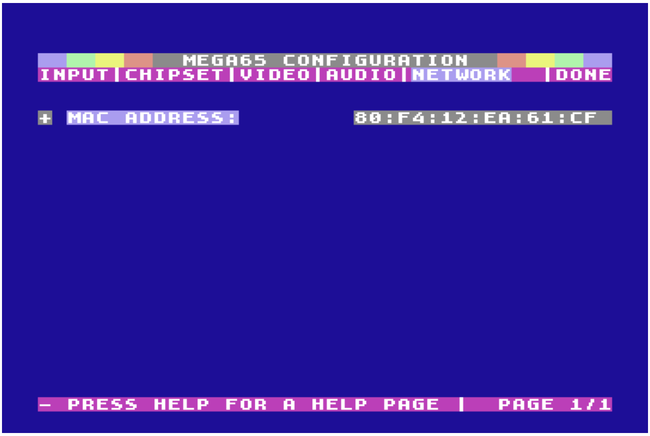
Swap stereo channels switches the stereo mix to use the opposite speakers.

Audio amplifier controls the built-in amplifier on the 3.5mm audio jack. Set this to **on** when using headphones or another device that expects an amplified signal. Set this to **off** for a line-level signal.

NETWORK

The **Network** page gives you the opportunity to adjust the MAC address of the Ethernet port. The MEGA65 does not have a hardware-assigned MAC address. Instead, it uses the value entered here.

If the MAC address is set to all zeros, press the R key to generate a random address. Networking features will not function with a MAC address set to all zeros.



DONE

The **Done** page lets you exit the Configuration Utility. If you have made changes that you want to keep, select **Save as defaults and exit.** You can also abandon changes, restore the factory default settings, or completely restart to the onboarding screen.

When you exit the Configuration Utility, you will be prompted to "power-cycle" the computer. Switch the computer off, then switch it on again.

INTRODUCING SD CARDS

Your MEGA65 is equipped with two SD card slots: a full-size SD card slot inside the case accessible from the bottom of the computer, and a microSD card slot accessible from the rear of the computer. The MEGA65 uses the SD card for storing configuration settings, loading the operating system, updating the firmware, and storing your software and data as virtual disk images.

The MEGA65 includes a full-size SD card installed in the internal SD card slot, pre-populated with the operating system files and bundled software.[1] You can connect your MEGA65 and start using it immediately without setting up a new SD card. You can leave this SD card in place and pretend that it isn't there, as if your MEGA65 is a computer from the 1990s, with a hidden ability to store non-volatile data.

The MEGA65 only uses one of the two SD card slots at one time. If there is a microSD card in the rear slot, the internal SD card is ignored. Which slot you use depends on how you expect to use the computer. As you get more familiar with your MEGA65, you may want to move the SD card between the MEGA65 and your PC to copy files and perform system updates. This is more convenient with the external microSD card slot.

Alternatively, you can connect your MEGA65 to your PC or local network with an Ethernet cable, and use a tool to transfer files between the two computers. The file transfer feature accesses files on the SD card, and uses whichever card slot is active. For more on transferring files, see chapter 7 on page 77.

PREPARING A NEW SD CARD

You can use the microSD memory card slot on the rear of the MEGA65 as persistent storage for the computer's configuration and system files. Having a prepared card in this slot overrides the SD card installed inside the computer. Having a microSD card installed is convenient if you wish to move it between your MEGA65 and your PC.

The following instructions apply to memory cards in either the external microSD card slot or the internal full-size SD card slot.

The MEGA65 supports SD cards of type SDHC, with sizes between 4 gigabytes and 32 gigabytes. Older cards smaller than 4GB and newer SDXC cards larger than 32GB are not expected to work.

An SD card must be prepared by the MEGA65 before use, using the SD Card Utility. The utility creates two partitions: a hidden partition for configuration and

[1] You can recreate the original SD card's contents using files that you can download from the Internet. Nevertheless, you may wish to make a backup of the SD card contents onto your PC.

freeze state data, and a FAT32-compatible partition for disk images and system files. You can access the FAT32 partition by connecting the SD card to your PC.[2]

An SD card formatted by another computer will *not* work with the MEGA65, even if it only erases the FAT32 partition. You *must* use the MEGA65 SD Card Utility to format the card.

INSERTING THE SD CARD

Formatting an SD card erases its contents, and this operation cannot be undone. We recommend that you do not erase the internal SD card that came with the computer.

The SD Card Utility will prompt you to select which of the cards currently inserted in the computer to format. As a precaution, you may wish to remove the internal SD card before opening the SD Card Utility. You can reinstall it later, or leave it out of the machine until you need it. This is also a good opportunity to copy the bundled software files (with filenames that end in `.D81`) off of the internal SD card to your PC, so they can be copied back to the new SD card later.

The utility menu is accessible even if no valid SD card is present. You can bootstrap a new system using just a compatible SD card and the SD Card Utility.

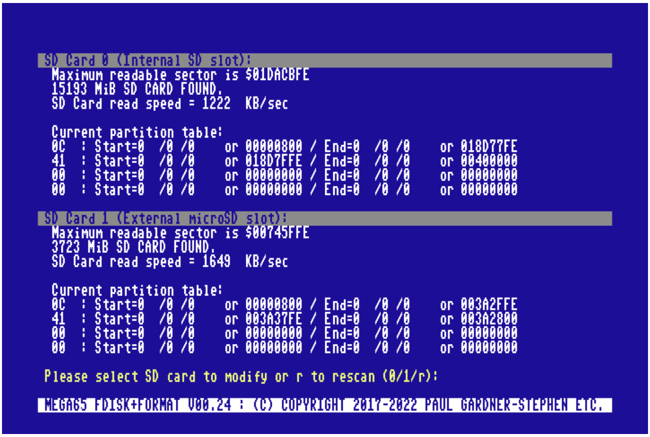
Insert the SD card that you wish to prepare before proceeding.

THE SD CARD UTILITY

You access the SD Card Utility from the Utility menu. Switch off the MEGA65, hold the ALT key and switch it on again. From the menu, select option 2 to start the SD Card Utility (`SDCARD FDISK+FORMAT UTILITY`).

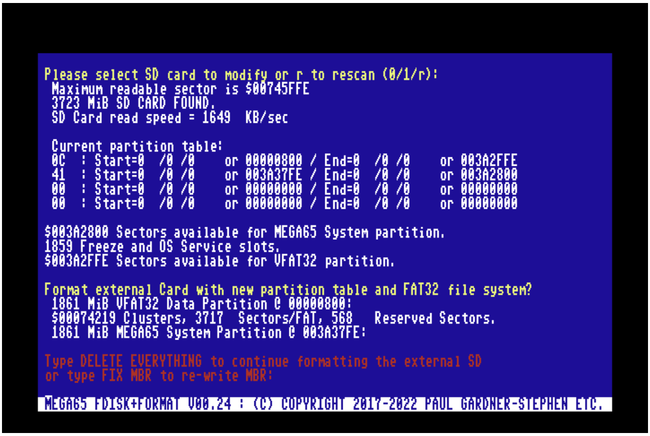
[2]If you wish to make a backup of the complete SD card including the hidden partition, you must use a disk utility that copies entire partitions, not just the files on the FAT32 partition.

The SD Card Utility opens and looks for SD cards installed in the slots. If you haven't inserted the SD card that you want to prepare yet, do so now, then press **R** to re-scan.

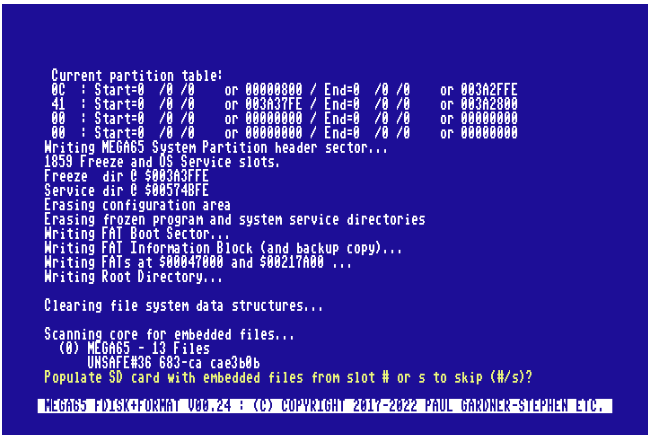


Select the card that you want to prepare: **0** for the internal SD card, **1** for the external microSD card. If you have two cards installed, *be careful to choose the correct card slot.*

The SD Card Utility prompts for confirmation to erase the SD card. As one last precaution, you must type the phrase `DELETE EVERYTHING` in all capital letters, then press **RETURN**, to proceed. (If you wish to abort this process, it is safe to switch off the MEGA65 at this time.)



The utility erases the SD card and sets up the partitions. When it is finished, it prompts to install the system files. The system files (with filenames ending in `.M65` and `.ROM`) are embedded in the core, and are copied to the FAT32 partition for use. If you have installed an updated MEGA65 core in slot 1, select it, otherwise select the factory-installed MEGA65 core in slot 0. (If you just received your MEGA65, slot 0 is the only option.)



When prompted, reboot the machine.[3]

[3] If you select a core that does not have `MEGA65.ROM` as one of the embedded files, the utility will prompt you to move the SD card to your PC to copy this file onto it. This only happens when using a MEGA65 core from somewhere other than an official MEGA65 release package. For more information about cores and obtaining `MEGA65.ROM`, see chapter 5 on page 47.

OBTAINING THE BUNDLED SOFTWARE

The system files copied to the freshly formatted SD card do not include the bundled software that was included with the original SD card in the internal card slot. You can use your PC to copy these files off of the original SD card, then copy them back onto the new SD card.

The MEGA65 Filehost website hosts all manner of files you can download for your MEGA65. This includes the latest versions of the platform components, alternate cores, and hundreds of games, demos, and applications produced by the MEGA65 community. This also includes the bundled software from the original SD card included with the computer.

If you no longer have the bundled software files, you can obtain them from the MEGA65 Filehost website. Visit the following URL:

`https://files.mega65.org/?id=all-intros-public`

CHAPTER 5

Upgrading the MEGA65

- How a MEGA65 Can Be Upgraded
- Determining the Versions of Things
- Obtaining the Latest Files
- The Core Selection Menu
- Upgrading the MEGA65 Core, ROM, and System Files
- Installing Alternate Cores and ROMs
- Setting Core Flags
- Erasing a Core Slot

- **Upgrading the Factory Core in Slot 0**
- **Understanding The Core Booting Process**

HOW A MEGA65 CAN BE UPGRADED

The MEGA65 platform consists of three major components:

1. The **MEGA65 core**, a description of the chipset to run on the FPGA
2. The **ROM**, code that defines the Commodore-style operating system (KERNAL) and BASIC
3. **System software** for features such as the Freezer menu

You can upgrade these components as new releases are published. You can also replace one or more of these components individually. In the case of the core and ROM, you can even have multiple versions installed simultaneously and switch between them. For example, instead of the latest MEGA65 ROM, you can switch to the original Commodore 65 prototype ROM. Or, you could switch to another core that causes your MEGA65 hardware to behave like a different computer entirely, such as a Commodore 64 or a ZX Spectrum.

The ROM and system software are files that reside on the SD card, and upgrading them is as simple as replacing the files. To upgrade the core, you use a process to install a core file into the MEGA65's core flash memory. This chapter describes this process.

WHAT IS A CORE?

The MEGA65 hardware architecture is based on a versatile chip called a "Field Programmable Gate Array," or FPGA. This is a special kind of computer chip that can be programmed to impersonate other chips. It does this by configuring a giant array of logic gates to reproduce circuits. FPGAs are not an emulation, but an electronic re-creation of other chips. FPGA code is sometimes referred to as *firmware*, a term you may recognize from modern computers and other devices.

Your MEGA65 was programmed at the factory to re-create a chipset based on the original Commodore 65, designed by the MEGA65 team. You can re-program the MEGA65 FPGA to upgrade to new versions of the MEGA65 chipset, or to replace the chipset with that of an entirely different computer!

Each possible chipset is known as a *core*. The MEGA65 can store up to eight cores, and you can switch between these cores by accessing a menu when you switch on the computer. You can also use this menu to load a new core from a file on the SD card, a process known as *flashing*.

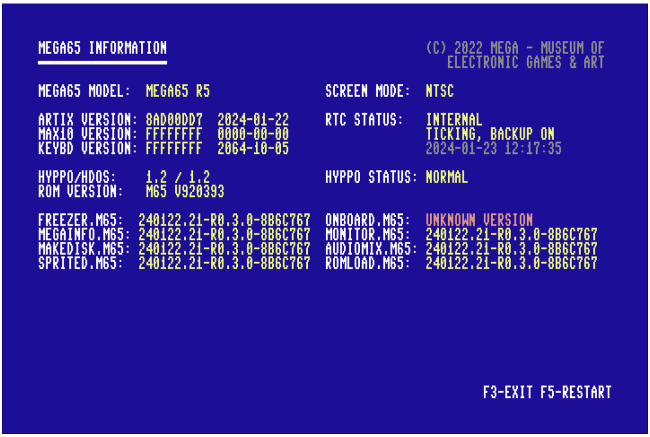
Members of the MEGA65 community have made several useful and fun alternate cores for the FPGA hardware. *C64 for MEGA65* by MJoergen and sy2002 re-creates the original Commodore 64 computer with a high degree of accuracy, perfect for running Commodore 64 games, demos, and applications. Other cores re-create the ZX Spectrum, the Game Boy, and even the original Galaga arcade machine hardware. The MEGA65's FPGA is powerful enough to re-create nearly all 8-bit home computers, and likely some 16-bit computers and consoles such as the Commodore Amiga. The MEGA65 hardware design, board layout, FPGA core, and other information are all available for free under various open-source licenses, so anyone is free to create other cores for the MEGA65 hardware.

DETERMINING THE VERSIONS OF THINGS

All components of the MEGA65 platform have a version identifier. The MEGA65 can display the version identifiers for all of its components using the MEGA65 Information utility.

To open the MEGA65 Information utility:

1. Switch on the MEGA65, and allow it to boot to BASIC.
2. Open the Freezer: press and hold RESTORE for one second then release it.
3. Press HELP. The MEGA65 Information utility will open.



Take note of these version identifiers:

Label and Example	Description
MEGA65 Model `MEGA65 R6`	The revision of the hardware. You need to know this when downloading new core files.
Artix Version `8AD00DD7 2024-01-22`	The currently running MEGA65 core. This is a string of eight letters and numbers, and also a build date.
ROM Version `M65 V920393`	The currently running ROM. For MEGA65 ROMs, this is a sequential number, with larger numbers representing newer releases.
System files (.M65) `240122.21-R0.3.0-8B6C767`	Each of the system software files has its own version identifier. Typically, you do not need to know these: you will upgrade these along with each core. The identifier is similar to the core version, but does not always match the currently running core.

Press F3 to exit to the Freezer, then F3 again to exit to BASIC.

Each core has a separate version for each hardware revision. As of the year 2024, the production models of the MEGA65 have used two different main board revisions, known as "R3" (more specifically "R3A") and "R6."[1]

The MEGA65 core is available for all hardware revisions. If you are installing an alternate core and it is not available for your hardware revision, contact the author of the core.

OBTAINING THE LATEST FILES

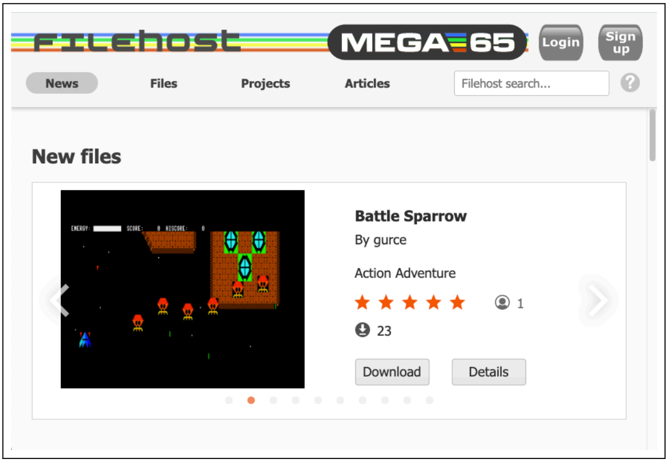
You can download the latest MEGA65 core, ROM, and system software from the MEGA65 Filehost website. Due to distribution restrictions for the Commodore 65 ROM code, some files require a Filehost account registered to a MEGA65 owner to access. All owners of the MEGA65 have a license to all versions of this ROM code.[2]

Visit the following URL in your web browser:

`https://files.mega65.org`

[1] The MEGA65 "DevKit" model sold in the year 2020 is revision "R3." It is also possible to run the MEGA65 core on certain FPGA development boards, with a separate version of the core file for each.

[2] There is a procedure for non-owners to get the latest MEGA65 ROM, such as to use with the Xemu MEGA65 emulator. This involves downloading C64 Forever Free Express Edition from Cloanto, extracting the original Commodore 65 prototype ROM file, then using a tool to apply a patch that you can download from Filehost. The full process is described in the following article: `https://mega65.org/rom-faq`



To register a Filehost account with your owner code:

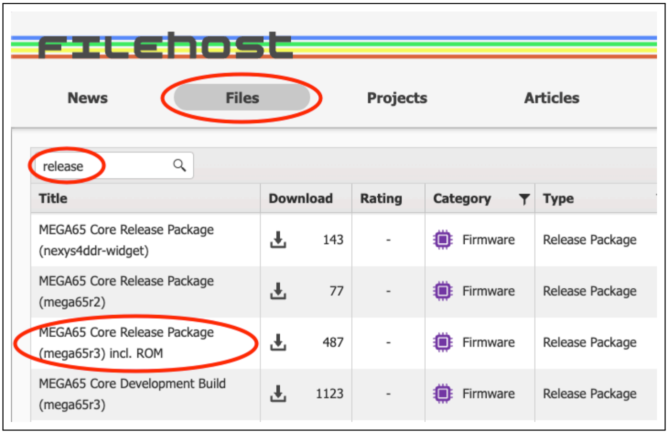
1. Visit the Filehost website. Click "Sign Up." Follow the prompts to create an account.
2. Locate your owner code. This is a code printed on a piece of paper that was included with your MEGA65 (possibly inserted into this manual). It looks something like this: `123-ABC-456`
3. Click the user icon in the upper-right corner of the Filehost screen. In the pop-up menu, select "Redeem Code." Enter your owner code as prompted.

To download the latest release package:

1. Click the "Files" tab of the Filehost website.
2. In the search box on the left-hand side, type: "release" The list will update to show only files with that word in the title.

3. Locate the entry named, "MEGA65 Core Release Package (mega65r6) incl. ROM," where "mega65r6" matches your hardware revision. (To confirm your hardware revision, open the Freezer menu, then press Help.)
4. Click the entry. Confirm that this release package is for your hardware revision, then click "Download" to download the file.

NOTE: There is an entry for the Release Package that does not include the ROM that is visible to everyone. To ensure you are using a compatible set of files, get the package that says "incl. ROM." If you don't see an entry that says "incl. ROM," check that you are signed in and that you have redeemed a valid owner code.



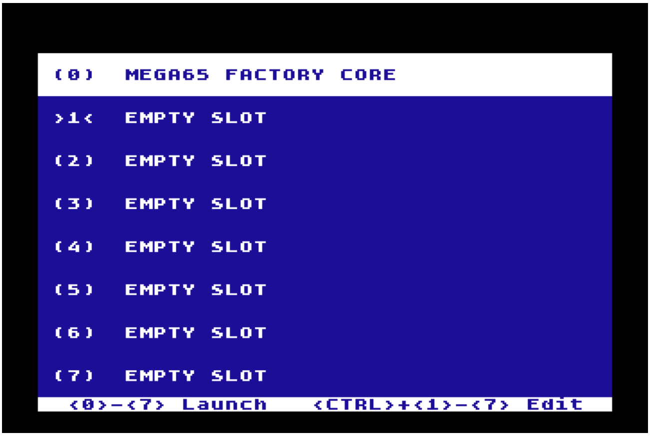
Extract the downloaded `.7z` archive. You should see a file whose name ends in `.cor`, and a folder of `sdcard-files` that includes one named `MEGA65.ROM`.

THE CORE SELECTION MENU

The MEGA65 decides which core to load into the FPGA when it starts up. You can interrupt this process to select which core to load.[3]

To open the core selection menu, switch off the computer, then hold the NO SCROLL key and switch on the computer. The core selection menu appears, with the eight core slots numbered 0 through 7.

[3] Technically, the MEGA65 starts the core in slot 0 to power the core selection menu. After you have made a selection or it chooses a default, it loads the selected core into the FPGA and continues the boot process.



You can select a core to boot using the cursor keys and RETURN, or you can simply press the number key that corresponds to the slot. The boot process continues with the new core. The MEGA65 will keep running the new core until you switch it off. (Pressing the reset button will not reset which core is being run.)

When you switch on the computer without opening the core selection menu, the MEGA65 looks for a default core. It first checks to see if any core is flagged as the default core (a setting you can change). If none are flagged, then it checks to see if there is a core in slot 1.[4] If the slot is empty, it uses slot 0.

Your computer comes with the MEGA65 core in slot 0 installed at the factory. It is recommended that you do not upgrade the factory-installed core unless advised to do so by the MEGA65 team. Instead, install new versions of the MEGA65 core in slot 1.

UPGRADING THE MEGA65 CORE, ROM, AND SYSTEM FILES

You can upgrade a core, or install a new core, from the core selection menu. This process reads the `.cor` file from the SD card.

To upgrade the MEGA65 core, ROM, and system files:

1. Remove the SD card (or microSD card) from the MEGA65, and connect it to your PC using an SD card reader.[5]

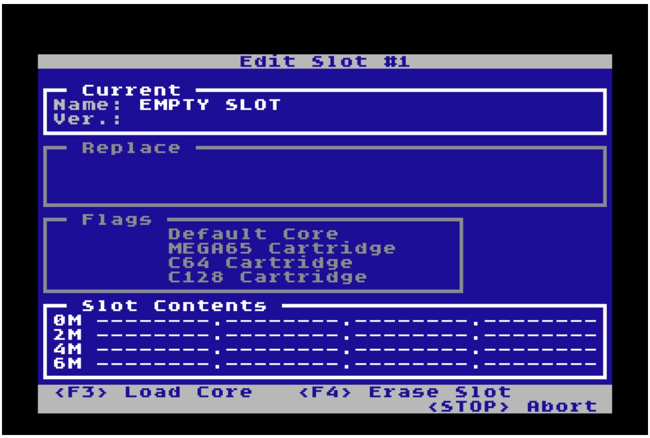
---

[4] If DIP switch #4 is in the "on" position, the MEGA65 checks slot 2 instead of slot 1. DIP switches are located inside the case, on the main board.

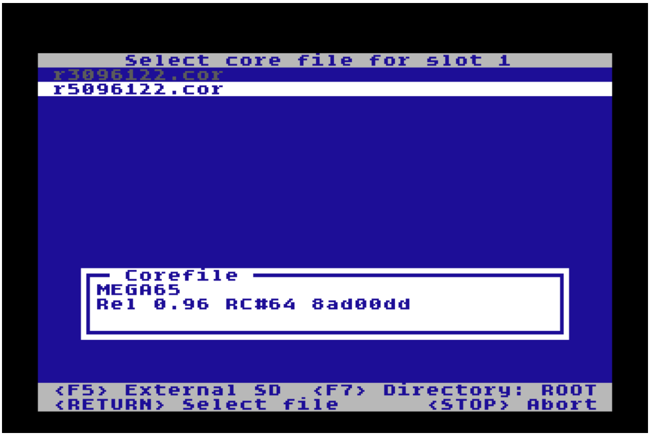
[5] As an alternative to moving the SD card to your PC, you can transfer files using an Ethernet connection. See chapter 7 on page 77.

2. Copy the `.cor` file that you extracted from the `.7z` archive to the SD card.
3. On your PC, open the `sdcard-files` folder from the `.7z` archive, then copy those files to the SD card, replacing the existing files. Put them in the root of the SD card's file system, not a sub-folder.
4. Eject the SD card from your PC's operating system, then move it back to the MEGA65.
5. Open the core selection menu: switch off the MEGA65, then hold NO SCROLL while switching it back on.
6. Hold CTRL then press the number of the slot you want to upgrade. The slot editor opens.
7. Press F3 to load a core file. The file selector opens. Use the cursor keys to select the `.cor` file, then press RETURN.
8. Press F8 to flash the core slot. Allow the flashing process to complete. This takes several minutes.
9. When the flashing process is complete, press any key to return to the core selection menu.

The slot editor looks like this:



When you load a core file, it prompts you to select the `.cor` file on a screen that looks similar to this:



Once you have selected the core, the slot editor shows the change it intends to make to the slot. After you start the flashing process, the display shows the progress.

NOTE: Do *not* switch off your computer or disconnect power until after this step is complete.

When the message "Core was successfully flashed" is displayed, the process is complete.

It is now safe to switch off your computer. Press any key to return to the core selection menu, or switch the computer off then on again to start the default core.

INSTALLING ALTERNATE CORES AND ROMS

Installing an alternate core, such as the C64 core, uses the same steps for flashing the core to a slot.

It is recommended to use slots 2 through 7 for alternate cores, and reserve slot 1 for the latest MEGA65 core. Of course, there is nothing stopping you from installing an alternate core in slot 1, so that the MEGA65 behaves as a different type of computer when you switch it on. You can always choose the MEGA65 core from the core selection menu.

You can keep more than one version of the MEGA65 ROM on the SD card. When booting the MEGA65 core, you can select one of these ROMs by holding down a number key during boot.

To install alternate ROMs, copy them to the root of the SD card with a filename such as `MEGA65x.ROM`, where `x` is a number between 0 and 7. To boot the alternate ROM, hold the corresponding number key down while the MEGA65 core starts. If you do not hold down a number, it boots to `MEGA65.ROM` by default.

There are several reasons you might want to keep alternate ROMs on your SD card:

- You are helping to test a new beta release of the ROM, and do not wish to make the beta version your default ROM.
- You want to try the original Commodore 65 prototype ROM. The MEGA65 core maintains backwards compatibility with the C65 ROM that was in

progress by Commodore before they cancelled the project. It is buggy and incomplete, but is still an interesting historical artifact.

- You want to try an alternate ROM developed by the MEGA65 community. One such ROM is the MEGA65 OpenROM, a project to create an all-new ROM released under an Open Source license without any original Commodore material.

Several alternate ROMs came with your MEGA65 SD card, installed at the factory. Try rebooting your computer while holding down a number key to see what happens!

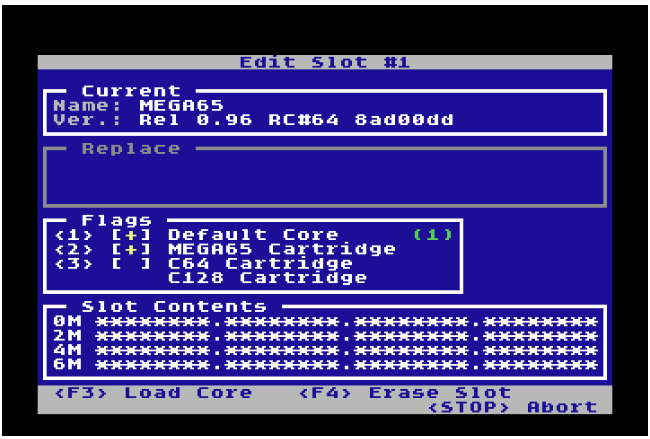
SETTING CORE FLAGS

There are several options ("flags") that you can select for a core in the core editor.

To change flags for a core, edit the core slot. Press the number key that corresponds to the flag to toggle its value. Save the flags to the slot by flashing the result: press F8. You can either set flags before flashing new core data, or you can flash just the new flag settings without replacing the core data.

To set a core to be the default core used when the MEGA65 is switched on without NO SCROLL held down, set the "Default core" flag. If no core is set as the default core, then slot 1 is used as the default (or slot 2 if DIP switch #4 is set to on).

The "cartridge" flags determine which core is selected when a cartridge is present in the expansion slot. This allows you to choose a different default core based on the type of the cartridge. For example, you can set the MEGA65 core to handle MEGA65 cartridges, and a different core to handle C64 cartridges. By default, the MEGA65 core will handle C64 cartridges using "GO64" mode. You may prefer to change this to use the C64 core that you install separately.



ERASING A CORE SLOT

The flashing process replaces whatever is in a core slot with the new core. If a core is already installed in the slot, flashing overwrites the existing core.

If you wish to delete a core and leave the slot empty, edit the slot, press F4 to set the replacement to "Erase slot," then press F8 to flash the slot with empty data.

UPGRADING THE FACTORY CORE IN SLOT 0

It is possible to upgrade the factory-installed MEGA65 core in slot 0. You only need to do this in rare cases, such as if a newer version of the MEGA65 core includes changes or bug fixes for the start-up process. It is recommended that you do not upgrade slot 0 unless the announcement for the release suggests that you do so. Most MEGA65 core upgrades are fully functional in slot 1, without needing to upgrade slot 0.

It is important that at least one core slot contains a functioning MEGA65 core. If something goes wrong during the flashing process, this may result in a non-functioning core in that slot. To help prevent accidents, the procedure for flashing slot 0 is slightly different from that of the other slots, and only an official MEGA65 core can be flashed to slot 0.

Please read these instructions carefully before starting the procedure. To upgrade the core in slot 0:

1. Install the latest MEGA65 core in slot 1, using the procedure described earlier. The core must be in the default non-zero slot to recover from any problems when updating slot 0.
2. Launch core slot 1 to confirm that it works.
3. Return to the core selection menu: switch off the MEGA65, then hold NO SCROLL while switching it back on.
4. Hold the and press the comma key to open the editor for slot 0.
5. Read the information screen, then type the word `CONFIRM` using uppercase letters and press RETURN.
6. Repeat the remainder of the flashing procedure to select the core file and flash the slot.

NOTE: If you have a revision R3A MEGA65 and have not previously upgraded slot 0, the MEGA and the comma key will not start the procedure: you have an older slot 0 core that does not have this feature. You can work around this by restarting the core selection menu with slot 1. From the core selection menu, prepare to hold down NO SCROLL, press the 1 key to boot into the core then immediately press and hold NO SCROLL. The core selection menu re-opens using slot 1. Press MEGA and the comma key to complete the slot 0 upgrade.

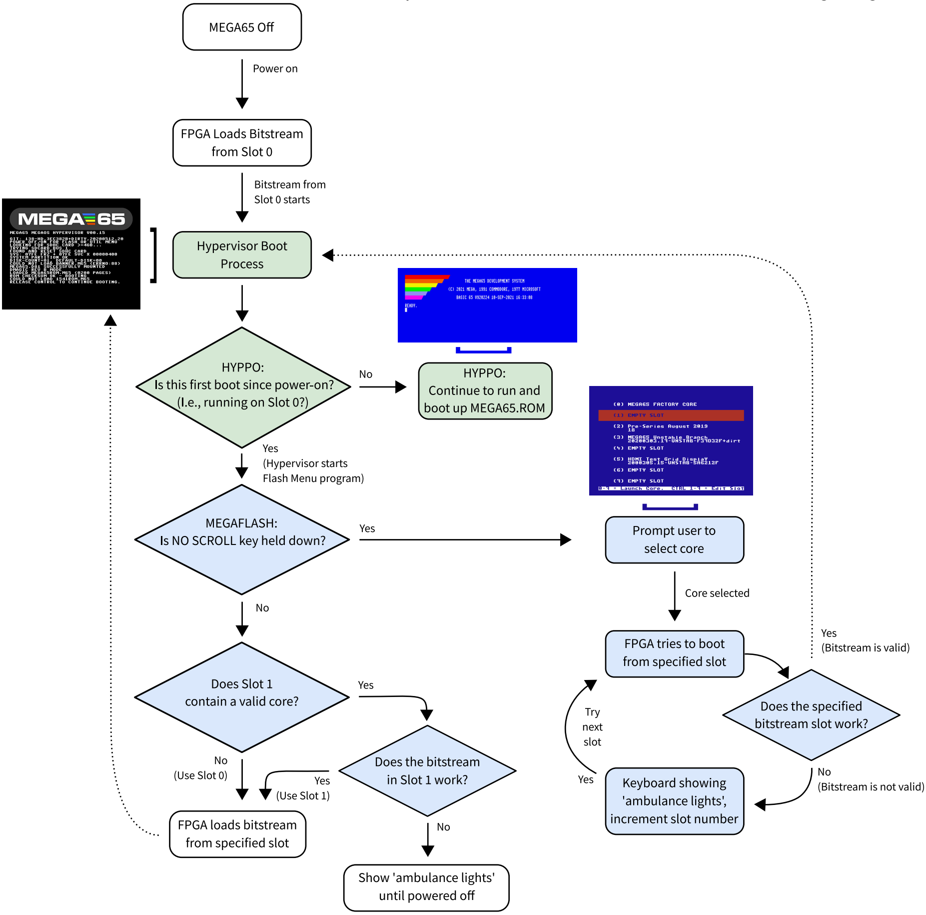
If something goes wrong during the slot 0 flashing process, your MEGA65 may not start correctly. Before doing anything else, switch on your MEGA65, and wait a minute or so. After a while, it should notice that there is no valid core in slot 0, then proceed to start the core in slot 1. You can hold NO SCROLL during this to open slot 1's core selection menu and restart the flashing process.

If the MEGA65 cannot boot any core after several minutes, it may be stuck. You may be able to recover using a device known as a "JTAG interface" that connects your PC to the MEGA65 main board. This allows you to inject a bitstream directly into the FPGA. The part is inexpensive but not always available. Contact the MEGA65 team on the Discord (`https://mega65.org/chat`) for assistance.

Core slot 0 cannot be assigned flags, such as to be the default core or to be associated with cartridge types. Slot 0 will be used for these purposes if no other core is installed. It is recommended that you keep the latest MEGA65 core in slot 1, in addition to flashing slot 0.

UNDERSTANDING THE CORE BOOTING PROCESS

This section summarises how the MEGA65 selects which core to start with when it is switched on. The process is shown in the following figure:



The booting process is governed by two facilities:

- The Hypervisor (also known as HYPPO), which operates at a level above the KERNAL. One of its responsibilities is to manage aspects of the boot process. For more details on the Hypervisor, refer to the **MEGA65 Book**. In the diagram, activities performed by the Hypervisor have been highlighted in green.

- The Core Selection Menu program (also known as "MegaFlash"), which provides a list of available core slots to choose from. In the diagram, activities performed by MegaFlash have been highlighted in blue.

When the MEGA65 is switched on, it does the following:

- Loads the bitstream stored in slot 0 of flash memory. If that is the MEGA65 Factory Core, the MEGA65 HYPPO Hypervisor starts.
- If it is the first boot since power-on (which implies that you are running from slot 0), HYPPO starts the Flash Menu program (aka MegaFlash) - but note that the Flash Menu in this mode may not show anything on the screen to indicate that it is running!
- The Flash Menu then checks if NO SCROLL is being held down.
- If it is, the Flash Menu program shows its display, allowing you to select or re-flash a core.
- If NO SCROLL is *not* being held down, the Flash Menu program checks if Flash Slot 1 contains a valid core.
- If it does, then the Flash Menu program attempts to load that core.
- If it succeeds, then the system reconfigures itself for that core, after which the behaviour of the system is according to that core.
- If it fails, the keyboard will go into "ambulance mode", showing flashing blue lights to indicate that some first-aid is required. Note that in ambulance mode the reset button has no effect: You must switch the MEGA65 off and on again.

If you have selected a different core in the Core Selection Menu, the process is similar, except that the ambulance lights will appear for only a limited time, as the FPGA will automatically search through the flash memory until it finds a valid core. If it gets to the end of the flash memory, it will start the MEGA65 Factory Core from slot 0 again.

CHAPTER 6

Using Disks and Disk Images

- Disk Drives
- Using Virtual Disk Images
- Using the Internal 3.5" Floppy Disk Drive
- Using External IEC Disk Drives
- Bootable Disks
- Accessing the SD Card from BASIC
- Common Disk Operations

DISK DRIVES

The MEGA65 has a built-in 3.5″ floppy disk drive, and supports Commodore-style external disk drives via the IEC serial port on the back of the computer. The IEC port also supports other external IEC storage devices, such as the SD2IEC. Some IEC storage devices can be connected in a chain and used at the same time.

The MEGA65 also includes a "virtual" disk drive that can mount D81 disk image files stored on the SD card. Most MEGA65 software that you download from the Internet is in the form of a D81 disk image. You can create a new D81 disk image directly from the MEGA65, and start saving your BASIC programs to the SD card without any additional hardware. You can also copy files between physical floppy disks and D81 disk images.

The Intro Disk Menu that you saw when you first switched on the computer is a program on a D81 disk image, a file named `MEGA65.D81` on the SD card. The MEGA65 is initially configured to boot this disk image automatically. You can change this in the Configuration Utility. (Refer back to chapter 4 on page 31.)

You can manage disk drives and virtual disk images from the Freezer menu. Some of these operations can be performed with BASIC commands such as **MOUNT**.

UNIT NUMBERS AND DRIVE NUMBERS

Each disk drive (physical or virtual) is accessed via a *unit* number. With vintage Commodore computers, the unit number refers to an IEC device connected to the computer. Commodore reserved unit numbers in the range 0 – 31 for devices of various purposes, with 8 – 11 reserved for disk drives. If you've ever used a Commodore 64 and typed `LOAD "*",8,1`, the "8" refers to the disk drive connected as unit 8. BASIC 65 disk commands use unit 8 by default, and accept a **U** parameter to change it, such as: `DLOAD "MYPROGRAM",U9`

With the MEGA65, you can assign a unit number to the virtual disk drive with a D81 disk image mounted, or to the internal 3.5″ floppy drive. You must mount a disk image or the internal 3.5″ floppy drive to a unit number before it can be used. Any message sent to a unit number assigned to a virtual disk or the internal floppy drive is handled by the MEGA65. All other messages are sent to the IEC serial port.

Disk commands also accept an optional parameter to specify a *drive* number. This is only needed when connecting a vintage dual floppy drive via the IEC port, such as the Commodore 4040, 8050, or 8250. Every disk drive assigns drive number 0 to the first drive. Dual-drive units assign a drive number of 1 to the second drive. Dual disk drives are usually equipped with an IEEE-488 interface, and need an IEEE-488 to IEC converter to be used on the MEGA65. BASIC 65 disk commands use drive 0 by default, and accept a **D** parameter to change it.

USING VIRTUAL DISK IMAGES

The MEGA65 provides two "managed drives" that supplement drives connected to the IEC port. The first managed drive can be assigned either a D81 disk image file on the SD card, or it can be assigned to the built-in 3.5" floppy drive. The second managed drive can also be assigned a D81 disk image file, for up to two virtual disks mounted at the same time.[1]

The first managed drive can be set to unit 8 or 10, and the second managed drive can be set to unit 9 or 11.

WHERE TO GET DISK IMAGE FILES

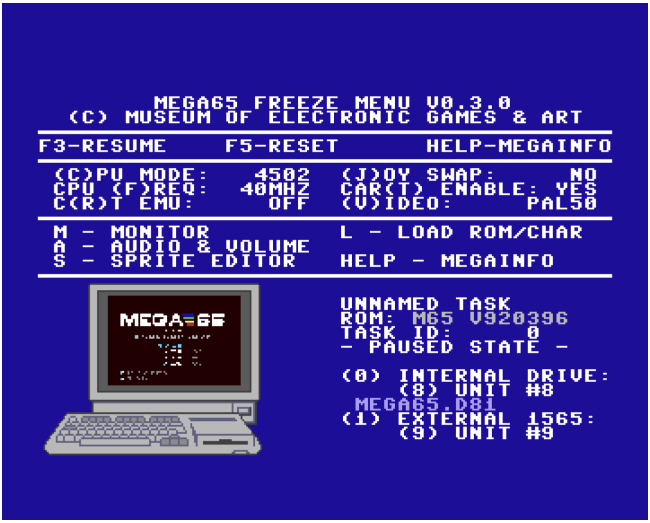
The MEGA65 Filehost website hosts a library of MEGA65 software produced by the community. You can browse or search for software, download a title, then copy the D81 disk image to the SD card using either your PC or the Ethernet file transfer tool.

https://files.mega65.org/

MOUNTING DISK IMAGES WITH THE FREEZER

Open the Freezer menu: hold RESTORE for one second, then release it. Notice the current drive mounting settings in the lower-right of the screen.

[1] Commodore originally intended to release a new external 3.5" floppy drive called the "1565" to go with the Commodore 65, connecting to a dedicated non-IEC port. The MEGA65 project has ambitions to someday produce such a drive, and if it does, this would be assigned to the second managed drive.



To mount a disk image on unit 8 or 10, select the first managed drive by pressing **0**. To mount a disk image on unit 9 or 11, select the second managed drive by pressing **1**. This opens the SD card file browser.

Use the cursor keys to select a D81 disk image, then press **RETURN**. The Freezer screen shows the selected disk image is now associated with the managed drive.

From the main Freezer screen, press **8** or **9** to toggle the unit number assigned to the first or second managed drive, respectively.

MOUNTING DISK IMAGES FROM BASIC

The BASIC **MOUNT** command can mount a D81 disk image from the SD card without having to open the Freezer. This command can be entered at the READY prompt, or be used as part of a program.

To mount a disk image on unit 8, enter **MOUNT** with the full filename in double-quotes, including the .D81 suffix:

```
MOUNT "MEGA65.D81"
```

To mount a disk image to unit 9, provide the **U** argument:

```
MOUNT "MEGA65.D81",U9
```

CREATING A NEW DISK IMAGE

You can create a new empty disk image from within the MEGA65 Freezer.

1. Open the Freezer.
2. Press **0** to select the first managed drive.
3. At the top of the file list, select: - NEW D81 DD IMAGE -
4. When prompted, enter a name for the disk. (Omit the .D81 suffix; this will be added automatically.)

The new disk image is created on the SD card and mounted to the first managed drive. It is formatted and ready to use.

MANAGING SD CARD FILES IN SUB-DIRECTORIES

Once you have spent some time on Filehost downloading games and applications, you will eventually have a large collection of D81 disk images on your SD card. You may wish to organize these files into sub-directories (folders). You can create these folders with the SD card connected to your PC, or with the Ethernet file transfer tool.

The Freezer supports sub-directories in its file browser. Each sub-directory name begins with a slash (/). Select a folder to list its files. To return to the previous folder, select: /..

You can also create new disk images in sub-directories by navigating to the sub-directory before selecting - NEW D81 DD IMAGE -.

The MEGA65 maintains a “current working directory” that is used as the base directory for BASIC commands such as **MOUNT**. To change the current working directory from BASIC, use the **CHDIR** command with the **U12** argument:

```
CHDIR "DEMOS",U12

MOUNT "XANADU.D81"
```

NOTE: Support for sub-directories on the SD card is a work in progress. If a disk image in a sub-directory is mounted, it will become un-mounted by any action that changes the current working directory. Some features that use files may not support files in sub-directories. We hope to improve this in a future update.

USING THE INTERNAL 3.5″ FLOPPY DISK DRIVE

The MEGA65 has a built-in 3.5″ floppy disk drive, similar to what was intended for the Commodore 65. You can use physical floppy disks to store your programs and data. Some MEGA65 software can be purchased on floppy disk.

The internal 3.5″ drive must be mounted before it can be used. It can be mounted to unit 8 or unit 10, in the first managed drive.

MOUNTING THE 3.5″ DRIVE WITH THE FREEZER

Open the Freezer menu: hold RESTORE for one second, then release it. Notice the current drive mounting settings in the lower-right of the screen.

Press 0, then use the cursor down key to: - `INTERNAL 3.5"` - Press RETURN to select it. The Freezer menu screen shows that the internal drive is mounted to the first managed disk device.

The `UNIT #` for the first device can be either 8 or 10. Press 8 to toggle between these options. BASIC disk commands default to unit 8, so it is typical to use unit 8 unless you are working with multiple disks at the same time.

The internal 3.5″ drive can only be mounted in the first managed drive with unit numbers 8 or 10. It cannot be mounted in the second managed drive (unit numbers 9 or 11).

MOUNTING THE 3.5″ DRIVE FROM BASIC

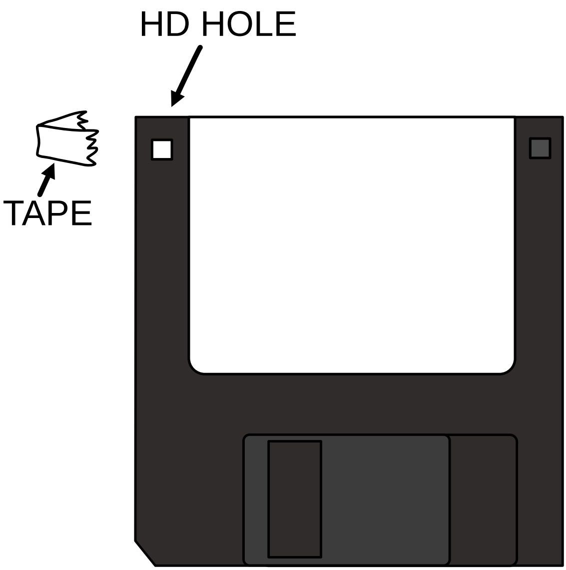
You can mount the internal 3.5″ disk drive to unit 8 using the BASIC **MOUNT** command. This command works from either the `READY` prompt or from a program. To mount the internal drive to unit 8, enter the command without arguments:

The **MOUNT** command can only mount the internal drive to unit 8. You can only mount it to unit 10 from the Freezer menu.

DD AND HD DISKS

The MEGA65 disk controller expects a Double Density (DD) floppy disk in the internal 3.5" floppy disk drive.[2] Floppy disks are no longer manufactured, and the DD variety can be difficult to find.

You can use a High Density (HD) floppy disk with the drive, with one important modification: you must cover both sides of the hole in the upper-left corner (as seen from the front) of the disk with a small piece of tape. This convinces the drive that the disk is DD, and switches it to a mode compatible with the MEGA65 disk controller. A double-density disk does not have a hole in this location.



NOTE: Make sure that the tape covers both sides of the hole.

[2] It may be possible to support full-capacity HD disks in a future firmware update. The drive hardware is capable of reading HD disks.

FORMATTING A DISK

A floppy disk must be formatted before it can be used. The MEGA65's internal 3.5" floppy drive emulates a Commodore 1581 drive, and can use disks formatted in such a drive. You can also format a disk with the MEGA65.

NOTE: Formatting a disk erases its contents. Be careful to only do this when you do not need the data on the disk!

To format a physical 3.5" floppy disk using the internal drive:

1. Open the Freezer.
2. Mount the internal 3.5" floppy drive to the first managed drive, unit 8.
3. *Double-check that unit 8 says:* - INTERNAL 3.5" -
4. Resume the computer: press **F3**.
5. Insert the floppy disk you wish to format into the internal floppy drive.
6. Enter the BASIC **FORMAT** command, giving it a name ("MYDISK") and a two-character ID (XX).

```
FORMAT "MYDISK",IXX
```

7. When prompted, enter YES and press RETURN.

Formatting the disk takes a minute or so. The drive will make buzzing and clicking noises during the process. Do not switch off the computer or eject the disk until formatting is complete.

You can confirm that the formatting was successful by issuing the **DIR** command. You should see an empty directory listing with the name and ID you specified. Your disk is now ready to use.

USING EXTERNAL IEC DISK DRIVES

The MEGA65 works with external disk drives connected to the IEC serial port.

External drives do not need to be mounted. If a unit number is not assigned to the internal 3.5" disk drive or to a disk image, disk operations intended for that unit number will be transmitted to the IEC serial port. It is up to the device connected to the port to recognize its unit number. Some IEC devices have switches that let you set the unit number. Others will only work with a specific number.

If you have an external drive that expects a specific unit number, you will need to make sure the MEGA65 isn't assigning that number to a disk image or the internal drive. Open the Freezer, then press 8 or 9 to toggle the unit number assignments so that they no longer use the needed unit number.

The drive and unit assignments are temporary, and will be reset to their defaults when the MEGA65 is switched off. You will need to re-configure the drive assignments the next time you switch on the computer.

BOOTABLE DISKS

With older Commodore computers, it was common for software makers to organize the file directory on a floppy disk such that the first file in the list is the main program. The user could then enter the command `LOAD "*",8,1` to load the main program, and `RUN` to run it. The asterisk is a wildcard that matches any file, so it matches the first file on the disk, without the user having to type the name of the program.

This method is still common, and the MEGA65 has a quick way to boot such disks: hold SHIFT and press RUN STOP. This executes the `RUN "*"` command, which is similar to the familiar command sequence that loads and runs the first program on the disk.

With the C65, Commodore introduced a new way to boot disks. Instead of relying on file order, a disk can have a file named `AUTOBOOT.C65`. If this file exists and is a program, the BASIC **BOOT** command will load and run this file.

```
BOOT
```

AUTO-BOOTING DISKS

As discussed in chapter 4 on page 31, you can use the Configuration Utility to set the MEGA65 to mount either a virtual disk image or the internal 3.5″ disk drive automatically during boot.

If the mounted disk is bootable — that is, it contains a program file named `AUTOBOOT.C65` — the MEGA65 will load and run the boot program automatically.

This is how the Intro Disk works. The Intro Disk menu is a program named `AUTOBOOT.C65` on the virtual disk image `MEGA65.D81`, which is pre-configured to be the mounted disk on system start-up. When you disable the Intro Disk from its menu, it renames `AUTOBOOT.C65` to `MENU`, such that the disk is no longer considered bootable.

Setting up a boot disk for yourself can be a handy way to configure your computer. You can write a short BASIC program that changes the system font, adjusts the background colour, and sets **KEY** macros to your taste, then save the program as `AUTOBOOT.C65` on a disk that you have configured to mount on system start-up. This program will run every time you switch on your MEGA65.

ACCESSING THE SD CARD FROM BASIC

Several BASIC 65 commands can operate directly on the MEGA65 SD card as if it were a disk drive. In these cases, the SD card is known as unit 12.

NOTE: Unit 12 can only be accessed directly for a few specific operations. It cannot treat the entire SD card as if it were a CBDOS disk.

To list all of the files on the SD card, use the **DIR** command with the `U12` argument:

```
DIR U12
```

You can use the optional **P** flag with this command to list the SD card files one page at a time. Press Q to stop at the current page, or any other key to advance to the next page.

```
DIR U12,P
```

To load or save a PRG file directly from the SD card (that isn't in a D81 disk image), use the `U12` argument with the **DLOAD** and **DSAVE** commands. You *must* include the `.PRG` filename suffix in this case, which is different to using PRG files on disks or disk images.

```
DLOAD "MYPROGRAM.PRG",U12
```

As shown earlier, the MEGA65 supports sub-directories (sub-folders) on the SD card, and maintains a current working directory for disk operations. To change the current working directory to a subdirectory:

```
CHDIR "SUBDIR",U12
```

To change the current working directory to the parent of the current directory:

```
CHDIR "..",U12
```

The **MOUNT** command can mount a D81 disk image to a unit number. Even though this command refers to a file on the SD card, it does not use the `U12` argument. Instead, it uses the **U** argument to set the unit number for the disk being mounted. The **MOUNT** command uses the current working directory set by **CHDIR** to locate the file.

COMMON DISK OPERATIONS

The following are some examples of common disk operations you can perform at the READY prompt. See the BASIC command reference in appendix A on page 87 for more information.

Most commands that accept filenames also accept a **U** argument that says which unit has the file. The default unit is 8.[3]

DIR

To display the directory (list of files) for a disk, use the **DIR** command.

```
DIR

DIR U9
```

Unlike the Commodore 64 method of loading the disk directory into BASIC memory, the **DIR** command does not modify BASIC memory. It is safe to use **DIR** with a program in memory.

To make larger directories easier to view, **DIR W** (for "wide") displays the directory in columns, pausing for each page.

DLOAD AND RUN

The **DLOAD** command loads a program from disk into memory. The **RUN** command runs the program currently in memory.

```
DLOAD "COOLGAME"
RUN
```

You can combine these into one command by providing the filename directly to the **RUN** command.

```
RUN "COOLGAME"
```

DSAVE

The **DSAVE** command saves the BASIC program currently in memory to disk.

[3] The default disk unit for BASIC commands is 8 when the computer first starts. You can change it with the **SET DEF** command.

```
DSAVE "MYGAME"
```

By default, this will not overwrite an existing file with the same name. To request that the existing file be overwritten, insert an @ (at) symbol before the filename, inside the double-quotes.

```
DSAVE "@MYGAME"
```

Note that save-with-replace is only recommended when using disk images and the 3.5" floppy drive. Older Commodore drives have bugs in this feature that could result in data loss.

BACKUP

The **BACKUP** command copies an entire disk from one unit to another. All existing data on the destination disk is erased as part of this process.

```
BACKUP U8 TO U9
```

You can use **BACKUP** to make disk images from floppy disks, or write disk images to floppy disks, or copy everything from one disk drive to another.

COPY

The **COPY** command makes a copy of a file. If the source and the destination are different filenames on the same unit, this duplicates the file on the disk.

```
COPY "MYGAME",U8 TO "MYGAME",U9

COPY "MYGAME" TO "MYGAME-V1"
```

RENAME

The **RENAME** command changes the name of an existing file.

```
RENAME "MYGAME-V29" TO "MYGAME-FINAL"
```

DELETE

The **DELETE** command deletes a file.

```
DELETE "JUNKFILE"
```

SHORTCUT DISK COMMANDS

BASIC 65 provides several shortcuts for common disk commands for use from the READY prompt.

Shortcut	Equivalent Command
/	**LOAD**
↑	**RUN**
←	**SAVE**
@	**DISK**
$	**DIR**

These are intended to be used with a directory listing to launch programs without having to type filenames. For example:

1. Display the disk's directory listing: type **$**, press RETURN.
2. Use the cursor keys to move the cursor to the line with the program you want to run.
3. Type ↑, press RETURN.

The selected program loads and runs. Notice that you do not have to clear extra characters from the line. The shortcut knows to ignore everything but the filename in double-quotes, as printed by the directory listing.

CHAPTER 7

Transferring Files

- Getting Files to the MEGA65
- Understanding Networking
- Obtaining M65Connect
- Enabling Network Listening
- Transferring Files

GETTING FILES TO THE MEGA65

While there is plenty of fun to be had writing your own programs for the MEGA65, eventually you will want to run programs written by others. You may also want to back up your MEGA65 programs to your PC for safe keeping.

The fastest and most reliable way to transfer files between your PC and your MEGA65 is with an Ethernet cable. You connect one end of the cable to the RJ45 jack on the rear of the MEGA65. You can connect the other end to your local area network (LAN) router or switch, or connect it directly to your PC. You use software on your PC to initiate file transfers, in either direction: from the PC to the MEGA65, or from the MEGA65 to the PC.

Alternatively, you can copy D81 virtual disk images to your MEGA65-formatted SD card using any PC with an SD card reader, without any other special tools or software. Your PC will recognize the data region of the SD card as a FAT32 partition. If you use this method, be aware that some PC operating systems may have unwanted side effects, such as fragmentation of SD card files, or extraneous files created by macOS Finder. These effects are harmless to the data, but may require maintenance to keep the card useful in the MEGA65. If the MEGA65 reports a fragmented file, you can use a PC disk defragmentation tool on the data partition. Alternatively, you can copy all files off of the SD card to the PC, re-format the SD card in the MEGA65, then copy the files back from the PC.

It is also possible to transfer files using a JTAG or UART Serial interface connected to the main board. This is an advanced technique and is not described in this User's Guide. JTAG or UART Serial hardware provides access to a debugging interface that may be useful to some programmers. JTAG is also useful for developing FPGA cores. For more information, see the *MEGA65 Developer's Guide*.

Most people will prefer the Ethernet method. This chapter describes how to do this.

UNDERSTANDING NETWORKING

The MEGA65 can use Ethernet to connect to or accept connections from other computers on a network. With appropriate software, it can connect to other computers over the Internet.

The MEGA65 Ethernet hardware presents a Media Access Control (MAC) address to the local network. Unlike other Ethernet hardware, the MEGA65's MAC address is not assigned at the factory: it is set in the Configuration Utility. (See chapter 4 on page 31.)

To transfer files, you instruct the MEGA65 to make itself available for incoming connections, then use the M65Connect app (or another tool, such as `mega65_ftp`) on your PC to initiate a connection. Your PC's operating system may prompt for permission to grant the tool access to the network when you run it for the first time. The tool uses UDP port 4510 to establish the initial connection with the MEGA65, and uses a self-assigned IPv6 address created from the MEGA65's MAC address for the file transfer session. This requires that IPv6 be enabled on the PC's network interface, which is the default in most cases.

As an alternative to connecting the MEGA65 to your local network, if your PC has an Ethernet jack, you can connect your MEGA65 directly to your PC with an Ethernet cable. This forms a small local network with no access to the Internet. The procedure for transferring files is the same with a direct connection as with a local network connection.

OBTAINING M65CONNECT

M65Connect is an application for Windows, Mac, or Linux that facilitates file transfers and other useful features for MEGA65 users. The application has a windowed interface, and also includes command-line tools useful for programming.

To obtain M65Connect:

1. Visit the MEGA65 Filehost website in a browser: `https://files.mega65.org`
2. In the search box in the top right corner, type: "M65Connect"
3. Select the version of M65Connect for your PC operating system.
4. Click the "Download" button.
5. Use your PC to unpack the downloaded archive file.

M65CONNECT FOR WINDOWS

The Windows version of M65Connect is in the "M65Connect" folder: **M65Connect.exe**. As with most open source software, Microsoft Defender may refuse to run the software, displaying a dialog window. If this happens, click "More info," then click the "Run anyway" button that appears.

The command-line tools are in a sub-folder named "M65Connect Resources," such as: `M65Connect Resources\mega65_ftp.exe`

M65CONNECT FOR MACOS

The macOS version of M65Connect is a Mac application bundle: **M65Connect.app**. As with most open source software, macOS does not recognize it as "signed" by the developer, and macOS will refuse to run it. You will need to remove the "quarantine" attribute to run the application.

In most versions of macOS, the best way to remove the quarantine attribute is with a Terminal command:

1. Move the M65Connect app to your Applications folder.
2. Open the Terminal app, included with macOS. This can be found in the Applications folder, in a sub-folder named Utilities.
3. Enter this command: `xattr -cr /Applications/M65Connect.app`

You can now double-click the M65Connect app to run it.

The command-line tools are inside the application bundle directory, such as: `/Applications/M65Connect.app/Contents/mega65_ftp.osx`

M65CONNECT FOR LINUX

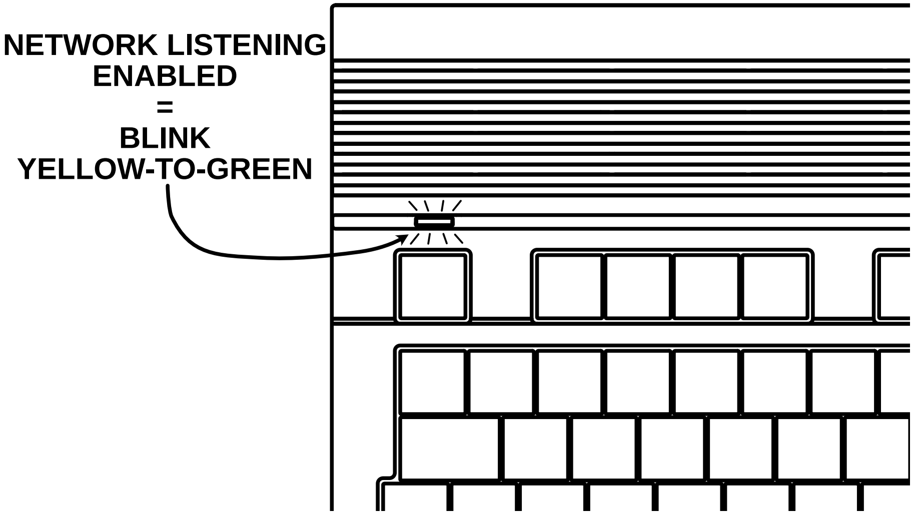
The Linux version of M65Connect is in the "M65Connect" folder: **M65Connect**. Double-click it to run.

The command-line tools are in a sub-folder named "M65Connect Resources," such as: `M65Connect Resources/mega65_ftp`

ENABLING NETWORK LISTENING

By default, the MEGA65 ignores all attempts by other computers to connect to it over the network. Software running on the MEGA65 can listen for network connections, but the MEGA65 does not do this on its own.

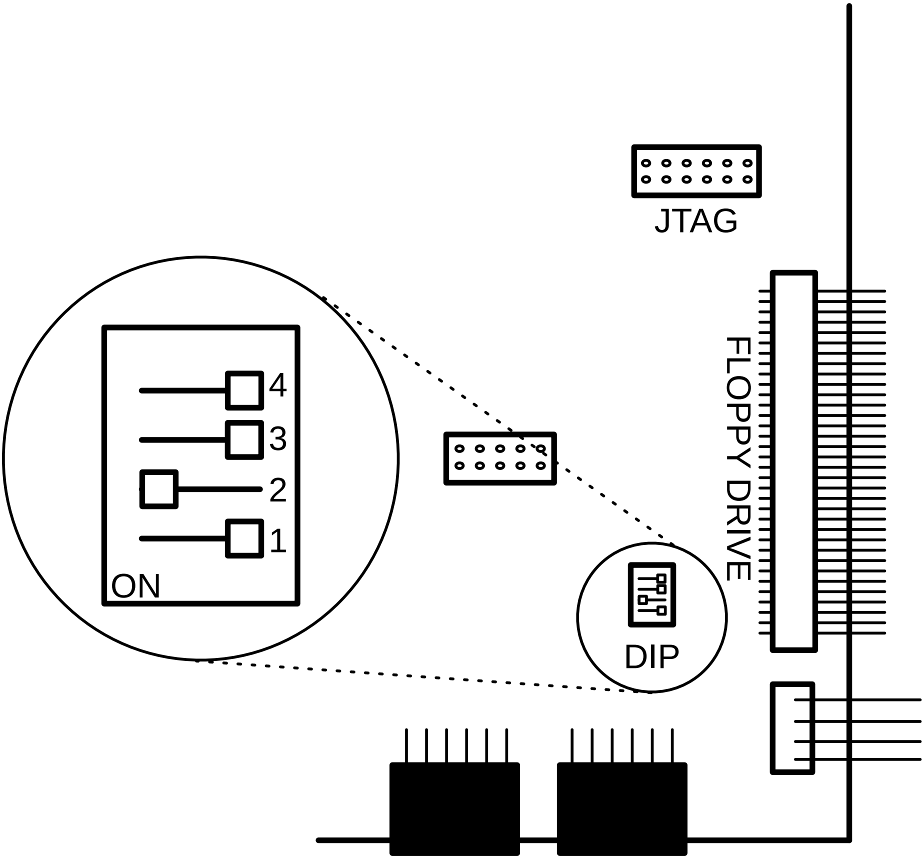
To transfer files with M65Connect, you must tell the MEGA65 to listen for incoming connection attempts from M65Connect. To enable a network listening session, press SHIFT + £. The power light blinks between yellow and green when network listening is active.



To disable network listening, press SHIFT + £ again, or reset the computer.

If the power light does not start blinking after pressing SHIFT + £, you may need to set DIP switch #2 on the main board. MEGA65s manufactured in the year 2024 and later should have this switch set at the factory. Earlier MEGA65s have this switch off by default.

To set the DIP switch, open the case, as described in chapter 2 on page 3. Locate the DIP switches on the main board, then set DIP switch #2 to the "on" position. Look for markings on the switches to identify switch #2 and the "on" direction. (The orientation of your DIP switches may differ from this diagram.)



It is safe to leave DIP #2 in this position for regular operation.

TRANSFERRING FILES

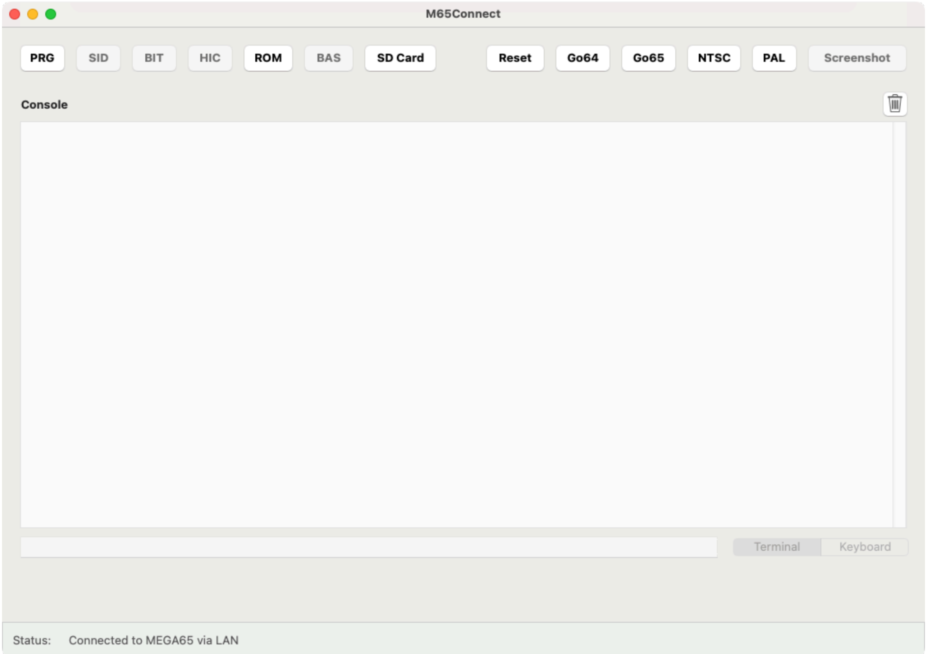
To transfer files, you will start a file transfer session using the M65Connect application or the `mega65_ftp` command-line tool. This connects to the MEGA65 and uploads a file transfer client for use during the session. When you end the session, the MEGA65 resets.

Starting a file transfer session resets the MEGA65. Be sure to save any programs or data before proceeding.

NOTE: If you clear memory by resetting the computer, remember to re-enable network listening: press SHIFT + £, and ensure the power light is blinking.

TRANSFERRING FILES WITH M65CONNECT

M65Connect detects automatically whether the MEGA65 is listening for connections. Open M65Connect, then enable the network listening session on the MEGA65. M65Connect reports a status of "Connected to MEGA65 via LAN," and several buttons including the **PRG** and **SD Card** buttons are enabled in the M65Connect window.

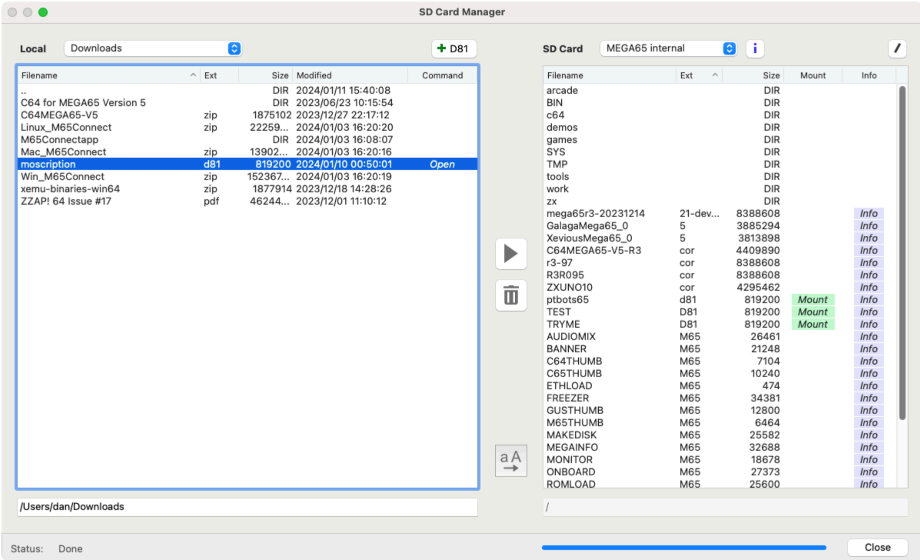


If M65Connect reports a status of "Not connected to MEGA65," check the following:

- The MEGA65 and the PC are connected to the same network, or directly to each other via a network cable.
- The MEGA65 is in network listening mode, with a blinking power light.
- In M65Connect, open the Settings menu, and select Connections. The "LAN Port" field should contain an IPv6 address. If it doesn't, wait a few seconds, or click the "Autodetect LAN Port" button.

To start a file transfer session, click the **SD Card** button. The SD Card Manager window opens.

NOTE: Starting a file transfer session resets the MEGA65 to load the file transfer utility. Be sure to save any data on the MEGA65 before starting the session.



Use the pane on the left to navigate files on your PC. Use the pane on the right to navigate files on the MEGA65 SD card. To transfer a file, select the file, then click the arrow button. The button indicates the direction the file will transfer.

You can also use M65Connect to create D81 disk images, and copy files to and from D81 disk images. Locate a D81 disk image on your PC or click the **+ D81** button to create one, then click the "Open" command in the file browser to open the disk image in the left pane. Transfer files to and from the image with the arrow button. Click the **X** button in the upper right to return to the file browser.

Click the **Close** button to end the file transfer session and close the SD Card Manager window. This resets the MEGA65.

THE MEGA65_FTP COMMAND-LINE TOOL

The `mega65_ftp` command-line tool initiates a file transfer session with the MEGA65. It can run interactively in the terminal and accept multiple file transfer commands, or it can run non-interactively with those commands provided as arguments.

To start an interactive file transfer session, run the `mega65_ftp` command, providing the -e argument to say you want to use an Ethernet connection.

NOTE: Starting a file transfer session resets the MEGA65 to load the file transfer utility. Be sure to save any data on the MEGA65 before starting the session.

```
% mega65_ftp -e
```

The tool will upload the file transfer client, and you will see it the client running on the MEGA65. If nothing happens, press Ctrl-C (on the PC) to abort, then double-check that the MEGA65 is connected and that network listening is enabled.

Once connected, the file transfer command prompt looks similar to this:

```
MEGA65 SD-Card:/>
```

To end the session, use the `exit` command. The tool will exit and return to the shell prompt, and the MEGA65 will reset.

```
MEGA65 SD-Card:/> exit
%
```

The following are several useful commands you can use during the file transfer session. Use the `help` command to see a complete list of available commands.

Command	**Description**
`put` *filename*	Send a file from the PC to the MEGA65.
`get` *filename*	Retrieve a file from the MEGA65 to the PC.
`dir`	Display a directory listing of the MEGA65 SD card.
`ldir`	Display a directory listing of the local current working directory.
`mkdir` *dirname*	Create a sub-directory on the MEGA65 SD card.
`cd` *dirname*	Change the current working directory on the MEGA65 SD card.
`lcd` *dirname*	Change the local current working directory.
`help`	Display a list of available commands.
`exit`	End the file transfer session.

To invoke `mega65_ftp` commands without starting an interactive prompt, use the `-c` argument once for each command:

```
% mega65_ftp -e -c 'put mydisk.d81' -c 'exit'
```

The tool will start a session, execute the commands, then terminate. Be sure to issue the `exit` command as the final command to reset the MEGA65, or reset the MEGA65 manually after the file transfer has completed.

APPENDIX **A**

BASIC 65 Command Reference

- **Commands, Functions, and Operators**
- **BASIC Command Reference**

COMMANDS, FUNCTIONS, AND OPERATORS

This appendix describes each of the commands, functions, and other callable elements of BASIC 65, which is an enhanced version of BASIC 10. Some of these can take one or more arguments, which are pieces of input that you provide as part of the command or function call, to help describe what you want to achieve. Some also require that you use special words.

Below is an example of how commands, functions, and operators (all of which are also known as keywords) will be described in this appendix.

KEY number**,** string

Here, **KEY** is a *keyword*. Keywords are special words that BASIC understands. In this manual, keywords are always written in **BOLD CAPITALS**, so that you can easily recognise them.

The "number" and "string" (in non-bold text) are examples of *arguments*. You replace these with values or algebraic phrases (*expressions*) that represent the data that controls the command's behavior.

Punctuation and other letters in bold text represent other characters that are typed as they appear. In this example, a comma must appear between the number argument and the string argument.

Here is an example of using the **KEY** command based on this pattern:

```
KEY 8,"LIST"+CHR$(13)
```

When you see square brackets around arguments, this indicates that the arguments are optional. You are not meant to type the square brackets. Consider this description of the **CIRCLE** command, which accepts optional arguments:

CIRCLE xc**,** yc**,** radius [**,** flags **,** start**,** stop]

The following examples of the **CIRCLE** command are both valid. They have different behavior based on their different arguments.

```
CIRCLE 100,150,30

CIRCLE 100,150,30,0,45,135
```

This arrangement of keywords, symbols, and arguments is called *syntax*. If you leave something out, or put the wrong thing in the wrong place, the computer will fail to understand the command and report a *syntax error*.

There is nothing to worry about if you get an error from the MEGA65. It is just the MEGA65's way of telling you that something isn't quite right, so that you can more easily find and fix the problem. For example, if you omit the comma in the **KEY** command, or replace it with a period, the MEGA65 will respond with a ?SYNTAX ERROR:

```
READY.
KEY 8"FISH"

?SYNTAX ERROR
READY.
KEY 8."FISH"

?SYNTAX ERROR
READY.
```

Expressions can be a number value such as 23.7, a string value such as "HELLO", or a more complex calculation that combines values, functions, and operators to describe a number or string value: "LIST"+CHR$(13)

It is important to use the correct type of expression when writing your programs. If you accidentally use the wrong type, the MEGA65 will display a ?TYPE MISMATCH ERROR, to say that the type of expression you gave doesn't match what it expected. For example, the following command results in a ?TYPE MISMATCH ERROR, because "POTATO" is a string expression, and a numeric expression is expected:

```
KEY "POTATO","SOUP"
```

Commands are statements that you can use directly from the READY. prompt, or from within a program, for example:

```
READY.
PRINT "HELLO"
HELLO

READY.
10 PRINT "HELLO"
RUN
HELLO
```

You can place a sequence of statements within a single line by separating them with colons, for example:

```
PRINT "HELLO" : PRINT "HOW ARE YOU?" : PRINT "HOW IS THE WEATHER?"
HELLO
HOW ARE YOU?
HOW IS THE WEATHER?
```

DIRECT MODE COMMANDS

Some commands only work in **direct mode** (sometimes called "immediate mode"). This means that the command can't be part of a BASIC program, but can be entered directly to the screen. For example, the **RENUMBER** command only works in direct mode, because its function is to renumber the lines of a BASIC program.

In the two **PRINT** examples above, the first was entered in direct mode, whereas the second one was part of a program. The **PRINT** command works in both immediate mode and in a program.

COMMAND SYNTAX DESCRIPTIONS

The following table describes the other symbols found in command syntax descriptions.

<table>
<tr><th>Symbol</th><th>Meaning</th></tr>
<tr><td>[ ]</td><td>Optional</td></tr>
<tr><td>...</td><td>The bracketed syntax can be repeated zero or more times</td></tr>
<tr><td>< | ></td><td>Include one of the choices</td></tr>
<tr><td>[|]</td><td>Optionally include one of the choices</td></tr>
<tr><td>{ , }</td><td>One or more of the arguments is required. The commas to the left of the last argument included are required. Trailing commas must be omitted. See CURSOR for an example.</td></tr>
<tr><td>[{ , }]</td><td>Similar to { , } but all arguments can be omitted</td></tr>
</table>

FONTS

Examples of text that appears on the screen, either typed by you or printed by the MEGA65, appear in the screen font: `"LIST"+CHR$(13)`

BASIC 65 CONSTANTS

Values that are typed directly into an expression or program are called *constants*. The values are "constant" because they do not change based on other aspects of the program state.

The following are types of constants that can appear in a BASIC 65 expression.

Type	Example	Example
Decimal Integer	32000	-55
Decimal Fixed Point	3.14	-7654.321
Decimal Floating Point	1.5E03	7.7E-02
Hex	$D020	$FF
Binary	%11010010	%101
String	"X"	"TEXT"

BASIC 65 VARIABLES

A program manipulates data by storing values in the computer's memory, referring to stored values, and updating them based on logic. In BASIC, elements of memory that store values are called *variables*. Each variable has a name, there are separate sets of variable names for each type of value.

For example, the variable AA can store a number value. The variable AA$ can store a string value. Commodore BASIC considers these to be separate variables, even though the names both begin with AA.

One way to store a value in a variable is with the assignment = operator. For example:

```
AA = 1.95

AA$ = "HELLO, "
```

Variable names must start with a letter, and contain only letters and numbers. They can be of any length, but Commodore BASIC only recognizes the first two letters of the name. SPEED and SP would be considered the same variable.

Variable names cannot contain any of the BASIC keywords. This makes using long names difficult: it is easy to use a keyword accidentally. For example, ENFORCEMENT is not a valid variable name, because **FOR** is a keyword. It is common to use short variable names to avoid these hazards.

A variable can be used within an expression with other constants, variables, functions, and operators. It is substituted with the value that it contains at that point in the program's execution.

```
10 INPUT "WHAT IS YOUR NAME";NA$
20 MSG$ = "HELLO, "+NA$+"!"
20 PRINT MSG$
```

Unlike some programming languages, BASIC variables do not need to be declared before use. A variable has a default value of zero for number type variables, or the empty string ("") for string type variables.

A variable that stores a single value is also known as a *scalar variable*. The scalar variable types and their value ranges are as follows.

Type	Name Symbol	Range	Example
Byte	&	0 .. 255	BY& = 23
Integer	%	-32768 .. 32767	I% = 5
Real	none	-1E37 .. 1E37	XY = 1/3
String	$	length = 0 .. 255	AB$ = "TEXT"

A variable whose name is a single letter followed by the type symbol (or no symbol for real number variables) is a *fast variable*. BASIC 65 stores the variable in a way that makes it faster to access or update the value than variables with longer names. It otherwise behaves like any other variable. This is also true for functions defined by **DEF FN**.

BASIC 65 ARRAYS

In addition to scalar variables, Commodore BASIC also supports a type of variable that can store multiple values, called an *array*.

The following example stores three string values in an array, then uses a **FOR** loop to **PRINT** a message for each element:

```
10 DIM NA$(3)
20 NA$(0) = "DEFT"
30 NA$(1) = "GARDNERS"
40 NA$(2) = "LYDON"
50 FOR I=0 TO 3
60 PRINT "HELLO, ";NA$(I);"!"
70 NEXT I
```

Each value in an array is referenced by the name of the array variable and an integer index. For example, AA(7) refers to the element of the array named AA() with index 7. Indexes are "zero-based:" the first element in the array has an index of 0. The index can be a numeric expression, which can be a powerful way to operate on multiple elements of data.

All values in an array must be of the same type. The type is indicated in the name of the variable, similar to scalar variables. AA() is an array of real numbers, AA$() is an array of strings.

Array variable names are considered separate from scalar variable names. The scalar variable AA has no relationship to the array variable AA().

BASIC needs to know the maximum size of the array before its first use, so that it can allocate the memory for the complete array. A program can declare an array's size using the **DIM** keyword, with the "dimensions" of the array. If an array variable is used without an explicit declaration, BASIC allocates a one-dimensional array of 10 elements, and the array cannot be re-dimensioned later (unless you **CLR** all variables).

An array can have multiple dimensions, each with its own index separated by a comma. The array must be declared with the maximum value for each dimension. Keep in mind that BASIC 65 allocates memory for the entire array, so large arrays may be constrained by available memory.

```
DIM BO$(3,3)
BO$(1,1) = "X"
BO$(0,0) = "O"
BO$(0,2) = "X"
BO$(1,0) = "O"
```

SCREEN TEXT AND COLOUR ARRAYS

A BASIC 65 program can place text on the screen in several ways. The **PRINT** command displays a string at the current cursor location, which is especially useful for terminal-like output. The **CURSOR** command moves the cursor to a given position. A program can use these commands together to draw pictures or user interfaces.

A program can access individual characters on the screen using the special built-in arrays **T@&()** and **C@&()**. These arrays are two-dimensional with indexes corresponding to the column and row of each character on the screen, starting from (0,0) at the top left corner.

T@&(column**,** row**)** is the screen code of the character. Screen codes are not the same as PETSCII codes. See appendix D on page 277 for a list of screen codes.

C@&(column**,** row**)** is the colour code of the character. This is an entry number of the system palette. See appendix E on page 281 for the list of colours in the default system palette. Upper bits also set text attributes, such as blinking.

Like regular arrays, the screen and colour array entries can be assigned new values, or used in expressions to refer to their current values.

```
10 FOR X=10 TO 30
20 T@&(X,2)=1
30 C@&(X,2)=INT(RND(1)*16)
40 NEXT X
50 PRINT "COLOUR AT POSITION 15: ";C@&(15,2)
```

The dimensions of these arrays depend on the current text screen mode. In 80 × 25 text mode, the column is in the range 0 – 79, and the row is in the range 0 – 24. The MEGA65 also supports 80 × 50 and 40 × 25 text modes.

BASIC 65 OPERATORS

An *operator* is a symbol or keyword that performs a function in an expression. It operates on one or two sub-expressions, called *operands*. The operator and its operands *evaluate to* the result of the operation.

For example, the * (asterisk) operator performs a multiplication of two number operands. The operator and its operands evaluate to the result of the multiplication.

```
A=6
PRINT A*7
```

The + (plus) operator has a different meaning depending on the type of the operands. If both operands are numbers, then the operator performs an addition of the numbers. If both operands are strings, then the operator evaluates to a new string that is the concatenation of the operands.

```
A=64
PRINT A+1

A$="MEGA"
PRINT A$+"65"
```

The - (minus) operator accepts either one operand or two operands. Given one number operand on the right-hand side, it evaluates to the negation of that number. Given two number operands, one on either side, it evaluates to the subtraction of the second operand from the first operand.

```
A=64
PRINT -A

PRINT A-16
```

The = symbol is used both as an assignment statement and as a relational operator. As an assignment, the = symbol is a statement that updates the value of a variable. The left-hand side must be a variable or array element reference, and its type must match the type of the expression on the right-hand side. The assignment is not an operator: it is not part of an expression.

```
AA=7
NA$="DEFT"
```

As a relational operator, the = symbol behaves as an expression. It evaluates the expressions on both sides of the operator, then tests whether the values are equal. If they are equal, the equality operator evaluates to -1, BASIC's representation of "true." If they are not equal, the operator evaluates to 0, or "false." The equality expression can be used with an **IF** statement to control program flow, or it can be used as part of a numeric expression. Both expressions must be of the same type.

```
100 IF X=99 THEN 130
110 X=X+1
120 GOTO 100
130 PRINT "DONE."
```

BASIC 65 knows the difference between assignment and equality based on context. Consider this line of code:

```
A = B = 10
```

BASIC 65 expects a statement, and notices a variable name followed by the = symbol. It concludes that this is a statement assigning a value to the number variable `A`. It then expects a number expression on the right-hand side of the assignment, and notices the = symbol is an operator in that expression. It concludes that the operation is an equality test, and proceeds to evaluate the expression and assign the result.

The operators **NOT**, **AND**, **OR** and **XOR** can be used either as logical operators or as boolean operators. A logical operator joins two conditional expressions as operands and evaluates to the logical comparison of their truth values.

```
IF X=99 OR Y<5 THEN 130

IF Y>10 AND Y<20 THEN 150
```

A boolean operator accepts two number operands and performs a calculation on the bits of the binary values.

```
A=17
PRINT A AND 20
```

Unlike other cases where operators have different behaviors based on how they are used, BASIC 65 does not need to determine whether these operators are behaving as logical operators or boolean operators. Because "true" and "false" are represented by carefully chosen numbers, the logical operators have the same behavior whether their operands are conditional expressions or numbers. A "true" conditional expression is the number -1, which internally is a binary number with all bits set. The logical expression "true and false" is equivalent to the binary boolean expression `%....0000 & %....1111`. In this case, the **AND** operator evaluates to 0, which is "false."

Conditional expressions evaluating to numbers can be used in some clever programming tricks. Consider this example:

```
A = A - (B > 7)
```

This statement will increment the value in the `A` by 1 if the value in `B` is greater than 7. Otherwise it leaves it unchanged. If the sub-expression `B > 7` is true, then it evaluates to -1. `A - (-1)` is equivalent to `A + 1`. If the sub-expression is false, then it evaluates to 0, and `A - 0` is equivalent to `A`.

When multiple operators are used in a single expression, the order in which they are evaluated is specified by *precedence*. For example, in the statement `A * A - B * B`, both multiplications will be performed first, then the subtraction. As in algebra, you can use parentheses to change the order of execution. In the expression `A * (A - B) * B`, the subtraction is performed first.

The complete set of operators and their order of precedence are summarised in the sections that follow.

Assignment Statement

Symbol	Description	Examples
`=`	Assignment	`A = 42, A$ = "HELLO", A = B < 42`

Unary Mathematical Operators

Name	Symbol	Description	Example
Plus	`+`	Positive sign	`A = +42`
Minus	`-`	Negative sign	`B = -42`

Binary Mathematical Operators

Name	Symbol	Description	Example
Plus	`+`	Addition	`A = B + 42`
Minus	`-`	Subtraction	`B = A - 42`
Asterisk	`*`	Multiplication	`C = A * B`
Slash	`/`	Division	`D = B / 13`
Up Arrow	`↑`	Exponentiation	`E = 2 ↑ 10`
Left Shift	`<<`	Left Shift	`A = B << 2`
Right Shift	`>>`	Right Shift	`A = B >> 1`

NOTE: The ↑ character used for exponentiation is entered with ↑, which is next to RESTORE.

Relational Operators

Symbol	Description	Example
`>`	Greater Than	`A > 42`
`>=`	Greater Than or Equal To	`B >= 42`
`<`	Less Than	`A < 42`
`<=`	Less Than or Equal To	`B <= 42`
`=`	Equal	`A = 42`
`<>`	Not Equal	`B <> 42`

Logical Operators

Keyword	Description	Example
`AND`	And	`A > 42 AND A < 84`
`OR`	Or	`A > 42 OR A = 0`
`XOR`	Exclusive Or	`A > 42 XOR B > 42`
`NOT`	Negation	`C = NOT A > B`

Boolean Operators

Keyword	Description	Example
`AND`	And	`A = B AND $FF`
`OR`	Or	`A = B OR $80`
`XOR`	Exclusive Or	`A = B XOR 1`
`NOT`	Negation	`A = NOT 22`

String Operator

Name	Symbol	Description	Operand type	Example
Plus	`+`	Concatenates Strings	String	`A$ = B$ + ".PRG"`

OPERATOR PRECEDENCE

Precedence	Operators
High	↑
	`+ -` (Unary Mathematical)
	`* /`
	`+ -` (Binary Mathematical)
	`<< >>` (Arithmetic Shifts)
	`< <= > >= = <>`
	`NOT`
	`AND`
Low	`OR XOR`

BASIC COMMAND REFERENCE

ABS

Format: **ABS**(x)

Returns: The absolute value of the numeric argument **x**.

x numeric argument (integer or real expression)

Remarks: The result is of type real.

Example: Using **ABS**

```
PRINT ABS(-123)
123
PRINT ABS(4.5)
4.5
PRINT ABS(-4.5)
4.5
```

AND

Format: operand **AND** operand

Usage: Performs a bit-wise logical AND operation on two 16-bit values.

Integer operands are used as they are. Real operands are converted to a signed 16-bit integer (losing precision). Logical operands are converted to 16-bit integer using $FFFF (decimal -1) for TRUE, and $0000 (decimal 0) for FALSE.

Expression	Result
0 AND 0	0
0 AND 1	0
1 AND 0	0
1 AND 1	1

Remarks: The result is of type integer. If the result is used in a logical context, the value of 0 is regarded as FALSE, and all other non-zero values are regarded as TRUE.

Examples: Using **AND**

```
PRINT 1 AND 3
1
PRINT 128 AND 64
0
```

AND can be used in **IF** statements to require multiple conditions.

```
IF (C >= 0 AND C < 256) THEN PRINT "BYTE VALUE"
```

APPEND

Format: **APPEND#** channel**,** filename [**,D** drive] [**,U** unit]

Usage: Opens an existing sequential file of type **SEQ** or **USR** for writing, and positions the write pointer at the end of the file.

channel number, where:

- **1** <= **channel** <= **127** line terminator is CR.
- **128** <= **channel** <= **255** line terminator is CR LF.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **APPEND#** works similarly to **DOPEN#... ,W**, except that the file must already exist. The content of the file is retained, and all printed text is appended to the end. Trying to **APPEND** to a non-existing file reports a DOS error.

Examples: Open existing file in append mode:

```
APPEND#5,"DATA",U9
APPEND#130,(DD$),U(UN%)
APPEND#3,"USER FILE,U"
APPEND#2,"DATA BASE"
```

ASC

Format: **ASC**(string)

Returns: The PETSCII code of the first character of the string argument, as a number.

Remarks: **ASC** returns zero for an empty string. This is different to BASIC 2, which raised an error for `ASC("")`.

The inverse function to **ASC** is **CHR$**. Refer to the **CHR$** function on page 114 for more information.

The name was apparently chosen to be a mnemonic to "ASCII," but the returned value is a PETSCII code.

Examples: Using **ASC**

```
PRINT ASC("MEGA")
77
PRINT ASC("")
0
```

ATN

Format: **ATN**(numeric expression)

Returns: The arc tangent of the argument.

The result is in the range ($-\pi/2$ to $\pi/2$)

Remarks: A multiplication of the result with $180/\pi$ converts the value to the unit "degrees". **ATN** is the inverse function to **TAN**.

Examples: Using **ATN**

```
PRINT ATN(0.5)
 .463647609
PRINT ATN(0.5) * 180 / π
 26.5650512
```

AUTO

Format: **AUTO** [step]

Usage: Enables or disables automatic line numbering during BASIC program entry. After submitting a new program line to the BASIC editor with

RETURN, the **AUTO** function generates a new BASIC line number for the entry of the next line. The new number is computed by adding **step** to the current line number.

step line number increment

Typing **AUTO** with no argument disables it.

Examples: Using **AUTO**

```
AUTO 10  : USE AUTO WITH INCREMENT 10
AUTO     : SWITCH AUTO OFF
```

BACKGROUND

Format: **BACKGROUND** colour

Usage: Sets the background colour of the screen.

colour the palette entry number, in the range 0 – 255

All colours within this range are customisable via the **PALETTE** command. On startup, the MEGA65 only has the first 32 colours configured. See appendix E on page 281 for the list of colours in the default system palette.

Example: Using **BACKGROUND**

```
BACKGROUND  3 : REM SELECT BACKGROUND COLOUR CYAN
```

BACKUP

Format: **BACKUP U** source **TO U** target
BACKUP D source **TO D** target [**,U** unit]

Usage: Copies one disk to another.

The first form of **BACKUP**, specifying units for source and target, can only be used for the drives connected to the internal FDC (Floppy Disk Controller). Units 8 and 9 are reserved for this controller. These can be either the internal floppy drive (unit 8) and another floppy drive (unit 9) attached to the same ribbon cable, or mounted D81 disk images. **BACKUP** can be used to copy from floppy to floppy, floppy to image, image to floppy and image to image, depending on image mounts and the existence of a second physical floppy drive.

The second form of **BACKUP**, specifying drives for source and target, is meant to be used for dual drive units connected to the IEC bus. For example: CBM 4040, 8050, 8250 via an IEEE-488 to IEC adapter. In this case, the backup is then done by the disk unit internally.

source unit or drive # of source disk.
target unit or drive # of target disk.

Remarks: The target disk will be formatted and an identical copy of the source disk will be written.
BACKUP cannot be used to backup from internal devices to IEC devices or vice versa.

Examples: Using **BACKUP**

```
BACKUP U8 TO U9      : REM BACKUP INTERNAL DRIVE 8 TO DRIVE 9
BACKUP U9 TO U8      : REM BACKUP DRIVE 9 TO INTERNAL DRIVE 8
BACKUP D0 TO D1, U10 : REM BACKUP ON DUAL DRIVE CONNECTED VIA IEC
```

BANK

Format: **BANK** bank number

Usage: Selects the memory configuration for BASIC commands that use 16-bit addresses. These are **LOAD**, **LOADIFF**, **PEEK**, **POKE**, **SAVE**, **SYS**, and **WAIT**. Refer to the system memory map in the **MEGA65 Book** for more information.

Remarks: A value > 127 selects memory mapped I/O. The default value at system startup for the bank number is 128. This configuration has RAM from $0000 to $1FFF, the BASIC and KERNAL ROM, and I/O from $2000 to $FFFF.

Example: Using **BANK**

```
BANK 1   :REM SELECT MEMORY CONFIGURATION 1
```

BEGIN

Format: **BEGIN** ... **BEND**

Usage: The beginning of a compound statement to be executed after **THEN** or **ELSE**. This overcomes the single line limitation of the standard **IF** ... **THEN** ... **ELSE** clause.

Remarks: Do not jump with **GOTO** or **GOSUB** into a compound statement, as it may lead to unexpected results.

Example: Using **BEGIN** and **BEND**

```
10 GET A$
20 IF A$>="A" AND A$<="Z" THEN BEGIN
30 PW$=PW$+A$
40 IF LEN(PW$)>7 THEN 90
50 BEND :REM IGNORE ALL EXCEPT (A-Z)
60 IF A$<>CHR$(13) GOTO 10
90 PRINT "PW=";PW$
```

BEND

Format: **BEGIN** ... **BEND**

Usage: The end of a compound statement to be executed after **THEN** or **ELSE**. This overcomes the single line limitation of the standard **IF** ... **THEN** ... **ELSE** clause.

Remarks: The example below shows a quirk in the implementation of the compound statement. If the condition evaluates to **FALSE**, execution does not resume right after **BEND** as it should, but at the beginning of the next line. Test this behaviour with the following program:

Example: Using **BEGIN** and **BEND**

```
10 IF Z > 1 THEN BEGIN:A$="ONE"
20 B$="TWO"
30 PRINT A$;" ";B$;:BEND:PRINT " QUIRK"
40 REM EXECUTION RESUMES HERE FOR Z <= 1
```

BLOAD

Format: **BLOAD** filename [**,B** bank] [**,P** address] [**,R**] [**,D** drive] [**,U** unit]

Usage: Loads a file of type **PRG** into RAM at address P. ("Binary load.")

BLOAD has two modes: The flat memory address mode can be used to load a program to any address in the 28-bit (256MB) address range where RAM is installed. This includes the standard RAM banks 0 to 5, as well as the 8MB of "attic RAM" at address $8000000.

This mode is triggered by specifying an address at parameter P that is larger than $FFFF. The bank parameter is ignored in this mode.

For compatibility reasons with older BASIC versions, **BLOAD** accepts the syntax with a 16-bit address at P and a bank number at B as well. The attic RAM is out of range for this compatibility mode.

The optional parameter **R** (RAW MODE) does not interpret or use the first two bytes of the program file as the load address, which is otherwise the default behaviour. In RAW MODE every byte is read as data.

filename the name of a file. Either a quoted string such as "DATA", or a string expression in brackets such as (FI$).

bank specifies the RAM bank to be used. If not specified, the current bank, as set with the last **BANK** statement will be used.

address overrides the load address that is stored in the first two bytes of the **PRG** file.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **BLOAD** cannot cross bank boundaries.

BLOAD uses the load address from the file if no P parameter is given.

Examples: Using **BLOAD**

```
BLOAD "ML DATA", B0, U9
BLOAD "SPRITES"
BLOAD "ML ROUTINES", B1, P32768
BLOAD (FI$), B(BA%), P(PA), U(UN%)
BLOAD "CHUNK",P($8000000)        :REM LOAD TO ATTIC RAM
```

BOOT

Format: **BOOT** filename [**,B** bank] [**,P** address] [**,D** drive] [**,U** unit]
BOOT SYS
BOOT

Usage: Loads and runs a program or boot sector from a disk.

BOOT filename loads a file of type **PRG** into RAM at address P and bank B, and starts executing the code at the load address.

BOOT SYS loads the boot sector (512 bytes in total) from sector 0, track 1 and unit 8 to address $0400 in bank 0, and performs a `JSR $0400` afterwards (Jump To Subroutine).

BOOT with no parameters attempts to load and execute a file named AUTOBOOT.C65 from the default unit 8. It's short for **RUN "AUTO-BOOT.C65"**.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

bank specifies the RAM bank to be used. If not specified, the current bank, as set with the last **BANK** statement, will be used.

address overrides the load address, that is stored in the first two bytes of the **PRG** file.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Examples: Using **BOOT**

```
BOOT SYS
BOOT (FI$), B(BA%), P(PA), U(UN%)
BOOT
```

BORDER

Format: **BORDER** colour

Usage: Sets the border colour of the screen.

colour the palette entry number, in the range 0 – 255

All colours within this range are customisable via the **PALETTE** command. See appendix E on page 281 for the list of colours in the default system palette.

Example: Using **BORDER**

```
10 BORDER  4 : REM SELECT BORDER COLOUR PURPLE
```

BOX

Format: **BOX** x0,y0, x2,y2 [, solid]
BOX x0,y0, x1,y1, x2,y2, x3,y3 [, solid]

Usage: Bitmap graphics: draws a box.

The first form of **BOX** with two coordinate pairs and an optional **solid** parameter draws a simple rectangle, assuming that the coordinate pairs declare two diagonally opposite corners.

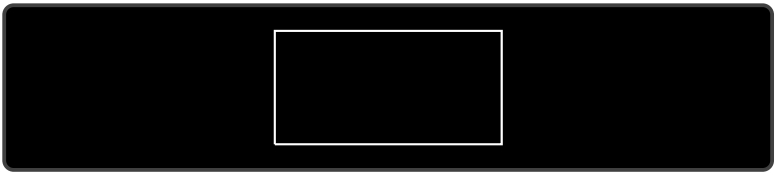
The second form with four coordinate pairs declares a path of four points, which will be connected with lines. The path is closed by connecting the last coordinate with the first.

The quadrangle is drawn using the current drawing context set with **SCREEN**, **PALETTE** and **PEN**. The quadrangle is filled if the parameter **solid** is not 0.

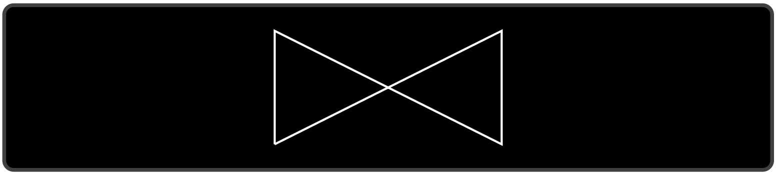
Remarks: **BOX** can be used with four coordinate pairs to draw any shape that can be defined with four points, not only rectangles. For example rhomboids, kites, trapezoids and parallelograms. It is also possible to draw bow tie shapes.

Examples: Using **BOX**

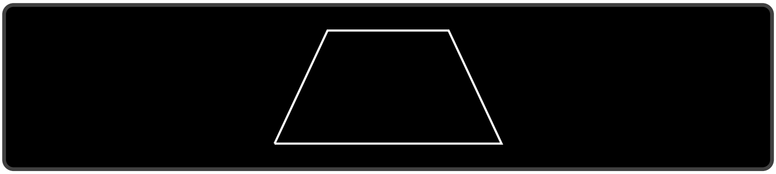
```
BOX 0,0, 160,0, 160,80, 0,80
```



```
BOX 0,0, 160,80, 160,0, 0,80
```



```
BOX 20,0, 140,0, 160,80, 0,80
```



BSAVE

Format: **BSAVE** filename**, P** start **TO P** end [**,B** bank] [**,D** drive] [**,U** unit]

Usage: Saves a memory range to a file of type **PRG**. ("Binary save.")

BSAVE has two modes: The flat memory address mode can be used to save a memory block in the 28-bit (256MB) address range where RAM is installed. This includes the standard RAM banks 0 to 5, as well as the 8MB of "attic RAM" at address $8000000.

This mode is triggered by specifying addresses for the start and end parameter P, that are larger than $FFFF. The bank parameter is ignored in this mode. This flat memory mode allows saving ranges greater than 64K.

For compatibility reasons with older BASIC versions, **BSAVE** accepts the syntax with 16-bit addresses at P and a bank number at B as well. The attic RAM is out of range for this compatibility mode. This mode cannot cross bank boundaries, so start and end address must be in the same bank.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`. If the first character of the filename is an at sign '`@`', it is interpreted as a "save and replace" operation. It is not recommended to use this option on 1541 and 1571 drives, as they contain a "save and replace bug" in their DOS.

start the first address, where the saving begins. It also becomes the load address, which is stored in the first two bytes of the **PRG** file.

end address where the saving ends. **end-1** is the last address to be used for saving.

bank the RAM bank to be used. If not specified, the current bank, as set with the last **BANK** statement, will be used.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: The length of the file is **end - start + 2**.
If the number after an argument letter is not a decimal number, it must be set in parenthesis, as shown in the third and fourth line of the examples.

The **PRG** file format that is used by **BSAVE** requires the load address to be written to the first two bytes. If the saving is done with a bank number that is not zero, or a start address greater than $FFFF, this information will not fit. For compatibility reasons, only the two low order bytes are written. Loading the file with the **BLOAD** command will then require the full 16-bit range of the load address as a parameter.

Examples: Using **BSAVE**

```
BSAVE "ML DATA", P 32768 TO P 33792, B0, U9
BSAVE "SPRITES", P 1536 TO P 2058
BSAVE "ML ROUTINES", B1, P($9000) TO P($A000)
BSAVE (FI$), B(BA%), P(PA) TO P(PE), U(UN%)
```

BUMP

Format: **BUMP**(type)

Returns: A bitfield of sprites currently colliding with other sprites (type=1) or screen data (type=2).

Each bit set in the returned value indicates that the sprite corresponding to that bit position was involved in a collision since the last call of **BUMP**. Calling **BUMP** resets the collision mask, so you will always get a summary of collisions encountered since the last call of **BUMP**.

Remarks: It's possible to detect multiple collisions, but you will need to evaluate the sprite coordinates to detect which sprites have collided.

Example: Using **BUMP**

```
10 S% = BUMP(1) : REM SPRITE-SPRITE COLLISION
20 IF (S% AND 6) = 6 THEN PRINT "SPRITE 1 & 2 COLLISION"
30 REM ---
40 S% = BUMP(2) : REM SPRITE-DATA COLLISION
50 IF (S% <> 0) THEN PRINT "SOME SPRITE HIT DATA REGION"
```

Sprite	Return	Mask
0	1	0000 0001
1	2	0000 0010
2	4	0000 0100
3	8	0000 1000
4	16	0001 0000
5	32	0010 0000
6	64	0100 0000
7	128	1000 0000

BVERIFY

Format: **BVERIFY** filename [**,P** address] [**,B** bank] [**,D** drive] [**,U** unit]

Usage: Compares a memory range to a file of type **PRG**. ("Binary verify.")

filename the name of a file. Either a quoted string such as "DATA", or a string expression in brackets such as (FI$).

bank specifies the RAM bank to be used. If not specified, the current bank, as set with the last **BANK** statement, will be used.

address is the address where the comparison begins. If the parameter P is omitted, it is the load address that is stored in the first two bytes of the **PRG** file that will be used.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **BVERIFY** can only test for equality. It gives no information about the number, or position of different valued bytes. In direct mode **BVERIFY** exits either with the message OK or with VERIFY ERROR. In program mode, a VERIFY ERROR either stops execution or enters the **TRAP** error handler, if active.

Examples: Using **BVERIFY**

```
BVERIFY "ML DATA", P 32768, B0, U9
BVERIFY "SPRITES", P 1536
BVERIFY "ML ROUTINES", B1, P(DEC("9000"))
BVERIFY (FI$), B(BA%), P(PA), U(UN%)
```

CATALOG

Format: **CATALOG** [filepattern] [**,W**] [**,R**] [**,D** drive] [**,U** unit]
$ [filepattern] [**,W**] [**,R**] [**,D** drive] [**,U** unit]

Usage: Prints a file catalog/directory of the specified disk.

The **W** (Wide) parameter lists the directory three columns wide on the screen and pauses after the screen has been filled with a page (63 directory entries). Pressing any key displays the next page.

The **R** (Recoverable) parameter includes files in the directory which are flagged as deleted but still recoverable.

filepattern is either a quoted string, for example: `"DA*"` or a string expression in brackets, e.g. `(DI$)`

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **CATALOG** is a synonym of **DIRECTORY** and **DIR**, and produces the same listing. The **filepattern** can be used to filter the listing. The wildcard characters * and **?** may be used. Adding **,T=** to the pattern string, with **T** specifying a filetype of **P**, **S**, **U** or **R** (for **P**RG, **S**EQ, **U**SR, **R**EL) filters the output to that filetype.

The shortcut symbol **$** can only be used in direct mode.

Examples: Using **CATALOG**

```
CATALOG
0 "BLACK SMURF      " BS 2A
508  "STORY PHOBOS"     SEQ
27   "C8096"            PRG
25   "C128"             PRG
104 BLOCKS FREE.
```

```
CATALOG "*,T=S"
0 "BLACK SMURF      " BS 2A
508  "STORY PHOBOS"     SEQ
104 BLOCKS FREE.
```

Below is an example showing how a directory looks with the **w**ide parameter:

```
DIR W
0 "BASIC EXAMPLES  "
1 "BEGIN"          P    1 "FREAD"        P    2 "PAINT.COR"     P
1 "BEND"           P    1 "FRE"          P    3 "PALETTE.COR"   P
1 "BUMP"           P    2 "GET#"         P    1 "PEEK"          P
1 "CHAR"           P    1 "GETKEY"       P    3 "PEN"           P
1 "CHR$"           P    1 "GET"          P    1 "PLAY"          P
4 "CIRCLE"         P    2 "GOSUB"        P    2 "POINTER"       P
1 "CLOSE"          P    2 "GOTO.COR"     P    1 "POKE"          P
1 "CLR"            P    2 "GRAPHIC"      P    1 "POS"           P
2 "COLLISION"      P    1 "HELP"         P    1 "POT"           P
1 "CURSOR"         P    1 "IF"           P    1 "PRINT#"        P
0 "DATA BASE"      R    2 "INPUT#"       P    1 "PRINT"         P
1 "DATA"           P    2 "INPUT"        P    1 "RCOLOR.COR"    P
1 "DEF FN"         P    2 "JOY"          P    1 "READ"          P
1 "DIM"            P    1 "LINE INPUT#"  P    1 "RECORD"        P
1 "DO"             P    3 "LINE"         P    1 "REM"           P
5 "ELLIPSE"        P    1 "LOOP"         P    1 "RESTORE"       P
1 "ELSE"           P    1 "MID$"         P    1 "RESUME"        P
1 "EL"             P    1 "MOD"          P    1 "RETURN"        P
1 "ENVELOPE"       P    1 "MOVSPR"       P    1 "REVERS"        S
2 "EXIT"           P    1 "NEXT"         P    3 "RGRAPHIC"      P
1 "FOR"            P    2 "ON"           P    1 "RMOUSE"        P
```

CHANGE

Format: **CHANGE /**findstring**/ TO /**replacestring**/** [**,** line range]
CHANGE "findstring**" TO "**replacestring**"** [**,** line range]

Usage: Edits the BASIC program that is currently in memory to replace all instances of one string with another.

An optional **line range** limits the search to this range, otherwise the entire BASIC program is searched. At each occurrence of the **find-string**, the line is listed and the user is prompted for an action:

- **Y** **RETURN** perform the replace and find the next string
- **N** **RETURN** do **not** perform the replace and find the next string
- ***** **RETURN** replace the current and all following matches
- **RETURN** exit the command, and don't replace the current match

Remarks: Almost any character that is not part of the string, including letters and punctuation, can be used instead of **/**.

However, using the double quote character finds text strings that are not tokenised, and therefore not part of a keyword.
For example, `CHANGE "LOOP" TO "OOPS"` will not find the BASIC keyword `LOOP`, because the keyword is stored as a token and not as text. However `CHANGE /LOOP/ TO /OOPS/` will find and replace it (possibly causing `SYNTAX ERROR`s).

Due to a limitation of the BASIC parser, **CHANGE** is unable to match the **REM** and **DATA** keywords. See **FIND**.

Can only be used in direct mode.

Examples: Using **CHANGE**

```
CHANGE "XX$" TO "UU$", 2000-2700
CHANGE /IN/ TO /OUT/
CHANGE &IN& TO &OUT&
```

CHAR

Format: **CHAR** column**,** row**,** height**,** width**,** direction**,** string [**,** address of character set]

Usage: Bitmap graphics: displays text on a graphic screen.

column (in units of character positions) is the start position of the output horizontally. As each column unit is 8 pixels wide, a screen width of 320 has a column range of 0 - 39, while a screen width of 640 has a column range of 0 - 79.

row (in pixel units) is the start position of the output vertically. In contrast to the column parameter, its unit is in pixels (not character positions), with the top row having the value of 0.

height is a factor applied to the vertical size of the characters, where 1 is normal size (8 pixels), 2 is double size (16 pixels), and so on.

width is a factor applied to the horizontal size of the characters, where 1 is normal size (8 pixels) 2 is double size (16 pixels), and so on. **direction** controls the printing direction:

- **1** up
- **2** right
- **4** down
- **8** left

The optional **address of character set** can be used to select a character set, different to the default character set at $29800, which includes upper and lower case characters.

Three character sets (see also **FONT**) are available:

- **$29000** Font A (ASCII)
- **$3D000** Font B (Bold)
- **$2D000** Font C (CBM)

The first part of the font (upper case / graphics) is stored at $xx000 – $xx7FF.

The second part of the font (lower case / upper case) is stored at $xx800 – $xxFFF.

string is a string constant or expression which will be printed. This string may optionally contain one or more of the following control characters:

Expression	Keyboard Shortcut	Description
`CHR$(2)`	CTRL+B	Blank Cell
`CHR$(6)`	CTRL+F	Flip Character
`CHR$(9)`	CTRL+I	AND With Screen
`CHR$(15)`	CTRL+O	OR With Screen
`CHR$(24)`	CTRL+X	XOR With Screen
`CHR$(18)`	RVSON	Reverse
`CHR$(146)`	RVSOFF	Reverse Off
`CHR$(147)`	CLR	Clear Viewport
`CHR$(21)`	CTRL+U	Underline
`CHR$(25)+"-"`	CTRL+Y + "-"	Rotate Left
`CHR$(25)+"+"`	CTRL+Y + "+"	Rotate Right
`CHR$(26)`	CTRL+Z	Mirror
`CHR$(157)`	Cursor Left	Move Left
`CHR$(29)`	Cursor Right	Move Right
`CHR$(145)`	Cursor Up	Move Up
`CHR$(17)`	Cursor Down	Move Down

Notice that the start position of the string has different units in the horizontal and vertical directions. Horizontal is in columns and vertical is in pixels.

Refer to the **CHR$** function on page 114 for more information.

Examples: Using **CHAR**

```
10 SCREEN 640,400,2
20 CHAR 28,180,4,4,2,"MEGA65",$29000
30 GETKEY A$
40 SCREEN CLOSE
```

Will print the text "MEGA65" at the centre of a 640 x 400 graphic screen.

CHARDEF

Format: **CHARDEF** index, bit-matrix

Usage: Changes the appearance of a character.

index is the screen code of the character to change (@:0, A:1, B:2, ...). See appendix D on page 277 for a list of screen codes.

bit-matrix is a set of 8 byte values, which define the raster representation for the character from top row to bottom row. If more than 8 values are used as arguments, the values 9 - 16 are used for the character index+1, 17 - 24 for index+2, etc.

Remarks: The character bitmap changes are applied to the VIC character generator, which resides in RAM at the address $FF7E000.

All changes are volatile and the VIC character set can be restored by a reset or by using the **FONT** command.

Examples: Using **CHARDEF**

```
CHARDEF 1,$FF,$81,$81,$81,$81,$81,$81,$FF :REM CHANGE 'A' TO RECTANGLE
CHARDEF 9,$18,$18,$18,$18,$18,$18,$18,$00 :REM MAKE 'I' SANS SERIF
```

CHDIR

Format: **CHDIR** dirname [**,U** unit]

Usage: Changes the current working directory.

dirname the name of a directory. Either a quoted string such as `"SOMEDIR"`, or a string expression in brackets such as `(DR$)`.

Dependent on the **unit**, **CHDIR** is applied to different filesystems.

UNIT 12 is reserved for the SD-Card (FAT filesystem). This command can be used to navigate to subdirectories and mount disk images that are stored there. **CHDIR "..",U12** changes to the parent directory on **UNIT 12**.

For other units managed by CBDOS (typically 8 and 9), **CHDIR** is used to change into or out of subdirectories on floppy or disk image of type **D81**. Existing subdirectories are displayed as filetype **CBM** in the parent directory, they are created with the command **MKDIR**. **CHDIR "/",U unit** changes to the root directory.

Examples: Using **CHDIR**

```
CHDIR "ADVENTURES",U12  :REM ENTER ADVENTURES ON SD CARD
CHDIR "..",U12          :REM GO BACK TO PARENT DIRECTORY
CHDIR "RACING",U12      :REM ENTER SUBDIRECTORY RACING
0 "MEGA65          "    1D
800  "MEGA65 GAMES"     CBM
800  "MEGA65 TOOLS"     CBM
600  "BASIC PROGRAMS"   CBM
960  BLOCKS FREE.

CHDIR "MEGA65 GAMES",U8 :REM ENTER SUBDIRECTORY ON FLOPPY DISK
CHDIR "/",U8            :REM GO BACK TO ROOT DIRECTORY
```

CHR$

Format: **CHR$**(numeric expression)

Returns: A string containing one character of the given PETSCII value.

Remarks: The argument range is from 0 - 255, so this function may also be used to insert control codes into strings. Even the NULL character, with code 0, is allowed.
CHR$ is the inverse function to **ASC**. The complete table of characters (and their PETSCII codes) is on page 261.

Example: Using **CHR$**

```
10 QUOTE$   = CHR$(34)
20 ESCAPE$  = CHR$(27)
30 PRINT QUOTE$;"MEGA65";QUOTE$ : REM PRINT "MEGA65"
40 PRINT ESCAPE$;"Q";       : REM CLEAR TO END OF LINE
```

CIRCLE

Format: **CIRCLE** xc, yc, radius [, flags , start, stop]

Usage: Bitmap graphics: draws a circle.

This is a special case of **ELLIPSE**, using the same value for horizontal and vertical radius.

xc the x coordinate of the centre in pixels

yc the y coordinate of the centre in pixels

radius the radius of the circle in pixels

flags controls filling, arcs and the position of the 0 degree angle. Default setting (zero) is don't fill, draw legs and the 0 degree radian points to 3 o' clock.

Bit	Name	Value	Action if set
0	fill	1	Fill circle or arc with the current pen colour
1	legs	2	Suppress drawing of the legs of an arc
2	combs	4	Let the zero radian point to 12 o' clock

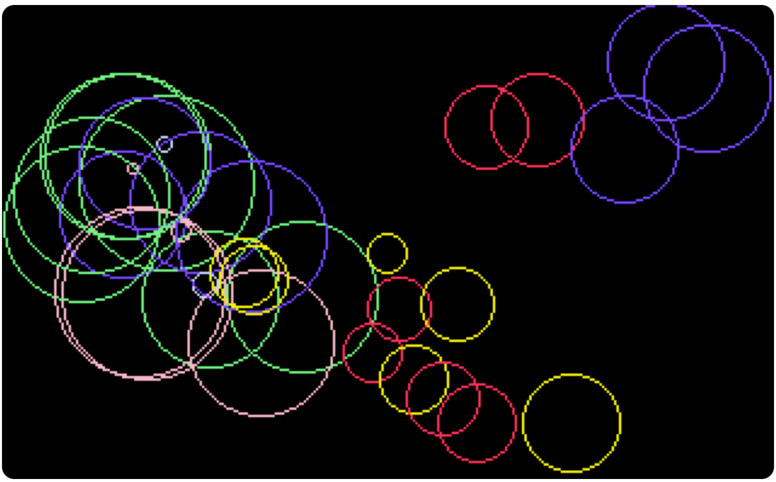
The units for the start- and stop-angle are degrees in the range of 0 to 360. The 0 radian starts at 3 o' clock and moves clockwise. Setting bit 2 of flags (value 4) moves the zero-radian to the 12 o' clock position.

start start angle for drawing an arc

stop stop angle for drawing an arc

Remarks: **CIRCLE** is used to draw circles on screens with an aspect ratio of 1:1 (for example: 320 x 200 or 640 x 400). Whilst using other resolutions (such as 640 x 200), the shape will be an ellipse instead.

The example program uses the random number function **RND** for circle colour, size and position. So it shows a different picture for each run.



Example: Using **CIRCLE**

```
100 REM CIRCLE (AFTER F.BOWEN)
110 BORDER 0                         :REM BLACK
120 SCREEN 320,200,4                 :REM SIMPLE SCREEN SETUP
130 PALETTE 0,0,0,0,0                :REM BLACK
140 PALETTE 0,1,RND(.)*16,RND(.)*16,15  :REM RANDOM COLOURS
150 PALETTE 0,2,RND(.)*16,15,RND(.)*16
160 PALETTE 0,3,15,RND(.)*16,RND(.)*16
170 PALETTE 0,4,RND(.)*16,RND(.)*16,15
180 PALETTE 0,5,RND(.)*16,15,RND(.)*16
190 PALETTE 0,6,15,RND(.)*16,RND(.)*16
200 SCNCLR 0                         :REM CLEAR
210 FORI=0TO32                       :REM CIRCLE LOOP
220 PEN 0,RND(.)*6+1                 :REM RANDOM PEN
230 R=RND(.)*36+1                    :REM RADIUS
240 XC=R+RND(.)*320:IF(XC+R)>319THEN240:REM X CENTRE
250 YC=R+RND(.)*200:IF(YC+R)>199THEN250:REM Y CENTRE
260 CIRCLE XC,YC,R,.                 :REM DRAW
270 NEXT
280 GETKEY A$                        :REM WAIT FOR KEY
290 SCREEN CLOSE:BORDER 6
```

CLOSE

Format: **CLOSE** channel

Usage: Closes an input or output channel.

channel number, which was given to a previous call of commands such as **APPEND**, **DOPEN**, or **OPEN**.

Remarks: Closing files that have previously been opened before a program has completed is very important, especially for output files. **CLOSE** flushes output buffers and updates the directory information on disks. Failing to **CLOSE** can corrupt files and disks. BASIC does *not* automatically close channels nor files when a program stops.

Example: Using **CLOSE**

```
10 OPEN 2,8,2,"TEST,S,W"
20 PRINT#2,"TESTSTRING"
30 CLOSE 2 : REM OMITTING CLOSE GENERATES A SPLAT FILE
```

CLR

Format: **CLR**
CLR variable

Usage: Clears BASIC variable memory.

After executing **CLR**, all variables and arrays will be undeclared. The run-time stack pointers and the table of open channels are also reset. **RUN** performs **CLR** automatically.

CLR variable clears (zeroes) the variable. **variable** can be a numeric variable or a string variable, but not an array.

Remarks: **CLR** should not be used inside loops or subroutines, as it destroys the return address. After **CLR**, all variables are unknown and will be initialised when they are next used.

Example: Using **CLR**

```
10 A=5: P$="MEGA65"
20 CLR
30 PRINT A;P$
RUN

 0
```

CLRBIT

Format: **CLRBIT** address**,** bit number

Usage: Clears (resets) a single bit at the **address**.

If the address is in the range of $0000 to $FFFF (0 - 65535), the memory bank set by **BANK** is used.

Addresses greater than or equal to $10000 (decimal 65536) are assumed to be flat memory addresses and used as such, ignoring the **BANK** setting.

The **bit number** is a value in the range of 0 - 7.

Remarks: **CLRBIT** is a short version of using a bitwise **AND** to clear a bit, but you can only clear one bit at a time. Refer to **SETBIT** to set a bit instead.

Example: Using **CLRBIT**

```
10 BANK 128         :REM SELECT SYSTEM MAPPING
20 CLRBIT $D011,4   :REM DISABLE DISPLAY
30 CLRBIT $D016,3   :REM SWITCH TO 38 OR 76 COLUMN MODE
```

CMD

Format: **CMD** channel [**,** string]

Usage: Redirects the standard output from screen to a channel.

This enables you to print listings and directories to other output channels. It is also possible to redirect this output to a disk file, or a modem.

channel number, which was given to a previous call of commands such as **APPEND**, **DOPEN**, or **OPEN**.

The optional **string** is sent to the channel before the redirection begins and can be used, for example, for printer or modem setup escape sequences.

Remarks: The **CMD** mode is stopped with **PRINT#**, or by closing the channel with **CLOSE**. It is recommended to use **PRINT#** before closing to make sure that the output buffer has been flushed.

Example: Using **CMD** to print a program listing:

```
OPEN 1,4    :REM OPEN CHANNEL #1 TO PRINTER AT UNIT 4
CMD 1
LIST
PRINT#1
CLOSE 1
```

COLLECT

Format: **COLLECT** [**,D** drive] [**,U** unit]

Usage: Rebuilds the Block Availability Map (BAM) of a disk, deleting splat files (files which have been opened, but not properly closed) and marking unused blocks as free.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: While this command is useful for cleaning a disk from splat files, it is dangerous for disks with boot blocks or random access files. These blocks are not associated with standard disk files and will therefore be marked as free and may be overwritten by further disk write operations.

Examples: Using **COLLECT**

```
COLLECT
COLLECT U9
COLLECT D0, U9
```

COLLISION

Format: **COLLISION** type [**,** line number]

Usage: Enables or disables a user-programmed interrupt handler for sprite collision.

With a handler enabled, a sprite collision of the given **type** interrupts the BASIC program and performs a **GOSUB** to **line number**. This handler must give control back with **RETURN**.

type the collision type for this interrupt handler:

Type	Description
1	Sprite - Sprite Collision
2	Sprite - Data - Collision
3	Light Pen

line number the line number of a subroutine which handles the sprite collision and ends with **RETURN**

A call without the line number argument disables the handler.

Remarks: It is possible to enable the interrupt handler for all types, but only one can execute at any time. An interrupt handler cannot be interrupted by another interrupt handler. Functions such as **BUMP**, **LPEN** and **RSPPOS** may be used for evaluation of the sprites which are involved, and their positions.

Info: **COLLISION** wasn't completed in BASIC 10. It is available in BASIC 65.

Example: Using **COLLISION**

```
10 COLLISION 1,70 : REM ENABLE
20 SPRITE 1,1 : MOVSPR 1,120,  0 : MOVSPR 1,0#5
30 SPRITE 2,1 : MOVSPR 2,120,100 : MOVSPR 2,180#5
40 FOR I=1 TO 50000:NEXT
50 COLLISION 1 : REM DISABLE
60 END
70 REM SPRITE <-> SPRITE INTERRUPT HANDLER
80 PRINT "BUMP RETURNS";BUMP(1)
90 RETURN: REM RETURN FROM INTERRUPT
```

COLOR

Format: **COLOR** colour

Usage: Sets the foreground text colour for subsequent **PRINT** commands.

colour the palette entry number, in the range 0 – 31

See appendix E on page 281 for the list of colours in the default system palette.

Remarks: This is another name for **FOREGROUND**.

Example: Using **COLOR**

```
COLOR 2
PRINT "THIS IS RED"
COLOR 3
PRINT "THIS IS CYAN"
```

CONCAT

Format: **CONCAT** appendfile [**,D** drive] **TO** targetfile [**,D** drive] [**,U** unit]

Usage: Appends (concatenates) the contents of the file **appendfile** to the file **targetfile**. Afterwards, **targetfile** contains the contents of both files, while **appendfile** remains unchanged.

appendfile is either a quoted string, for example: `"DATA"` or a string expression in brackets, for example: `(FI$)`

targetfile is either a quoted string, for example: `"SAFE"` or a string expression in brackets, for example: `(FS$)`

If the disk unit has dual drives, it is possible to apply **CONCAT** to files which are stored on different disks. In this case, it is necessary to specify the drive# for both files. This is also necessary if both files are stored on drive#1.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **CONCAT** is executed in the DOS of the disk drive. Both files must exist and no pattern matching is allowed. Only files of type **SEQ** may be concatenated.

Examples: Using **CONCAT**

```
CONCAT "NEW DATA" TO "ARCHIVE" ,U9
CONCAT "ADDRESS",D0 TO "ADDRESS BOOK",D1
```

CONT

Format: **CONT**

Usage: Resumes program execution after a break or stop caused by an **END** or **STOP** statement, or by pressing RUN STOP.

This is a useful debugging tool. The BASIC program may be stopped and variables can be examined, and even changed. The **CONT** statement resumes execution.

Remarks: **CONT** cannot be used if a program has stopped because of an error. Also, any editing of a program inhibits continuation. Stopping and continuation can spoil the screen output, and can also interfere with input/output operations.

Example: Using **CONT**

```
10 I=I+1:GOTO 10
RUN

BREAK IN 10
READY.
PRINT I
 947
CONT
```

COPY

Format: **COPY** source [**,D** drive] [**,U** unit] **TO** [target] [**,D** drive] [**,U** unit]

Usage: Copies a file to another file, or one or more files from one disk to another.

source is either a quoted string, e.g. `"DATA"` or a string expression in brackets, e.g. `(FI$)`.

target is either a quoted string, e.g. `"BACKUP"` or a string expression in brackets, e.g. `(FS$)`

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

If none or one unit number is given, or the unit numbers before and after the TO token are equal, **COPY** is executed on the disk drive itself, and the source and target files will be on the same disk.

If the source unit (before TO) is different to the target unit (after TO), **COPY** executes a CPU-driven routine that reads the source files into a RAM buffer and writes to the target unit. In this case, the target file name cannot be chosen, it will be the same as the source filename. The extended unit-to-unit copy mode allows the copying of single files, pattern matching files or all files of a disk. Any combination of units is allowed, internal floppy, D81 disk images, IEC floppy drives such as the 1541, 1571, 1581, or CMD floppy and hard drives.

Remarks: The file types **PRG**, **SEQ** and **USR** can be copied. If source and target are on the same disk, the target filename must be different to the source file name.

COPY cannot copy **DEL** files, which are commonly used as titles or separators in disk directories. These do not conform to Commodore DOS rules and cannot be accessed by standard **OPEN** routines.

REL files cannot be copied from unit to unit.

Examples: Using **COPY**

```
COPY U8 TO U9            :REM COPY ALL FILES
COPY "CODES" TO "BACKUP" :REM COPY SINGLE FILE
COPY "*.TXT",U8 TO U9    :REM PATTERN COPY
COPY "M*",U9 TO U11      :REM PATTERN COPY
```

COS

Format: **COS**(numeric expression)

Returns: The cosine of an angle.

The argument is expected in units of radians. The result is in the range (-1.0 to +1.0)

Remarks: A value in units of **degrees** can be converted to **radians** by multiplying it with $\pi/180$.

Examples: Using **COS**

```
PRINT COS(0.7)
 0.76484219

X=60:PRINT COS(X * π / 180)
 0.5
```

CURSOR

Format: **CURSOR** <**ON** | **OFF**> [{, column, row, style}]
CURSOR column, row

Usage: Moves the text cursor to the specified position on the current text screen.

ON or **OFF** displays or hides the cursor. When the cursor is **ON**, it will appear at the cursor position during **GETKEY**.

column and **row** specify the new position.

style sets a solid (1) or flashing (0) cursor.

Example: Using **CURSOR**

```
10  SCNCLR
20  CURSOR 1,2
30  PRINT "A"; : SLEEP 1
40  PRINT "B"; : SLEEP 1
50  PRINT "C"; : SLEEP 1
60  CURSOR 20,10
70  PRINT "D"; : SLEEP 1
80  CURSOR ,5            :REM MOVE THE CURSOR TO ROW 5 BUT DO NOT CHANGE THE COLUMN
90  PRINT "E"; : SLEEP 1
100 CURSOR 0              :REM MOVE THE CURSOR TO THE START OF THE ROW
110 PRINT "F"; : SLEEP 1
```

CUT

Format: **CUT** x, y, width, height

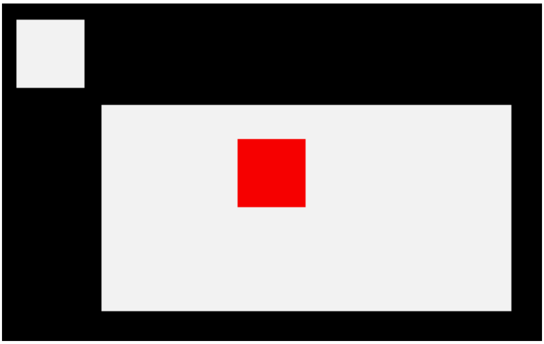
Usage: Bitmap graphics: copies the content of the specified rectangle with upper left position **x, y** and the **width** and **height** to a buffer, and fills the region afterwards with the colour of the currently selected pen.

The cut out can be inserted at any position with the command **PASTE**.

Remarks: The size of the rectangle is limited by the 1K size of the buffer. The memory requirement for a cut out region is width * height * number of bitplanes / 8. It must not equal or exceed 1024 byte. For a 4-bitplane screen for example, a 45 x 45 region needs 1012.5 byte.

Example: Using **CUT**

```
10 SCREEN 320,200,2
20 BOX 60,60,300,180,1  :REM DRAW A WHITE BOX
30 PEN 2                :REM SELECT RED PEN
40 CUT  140,80,40,40    :REM CUT OUT A 40 * 40 REGION
50 PASTE 10,10,40,40    :REM PASTE IT TO NEW POSITION
60 GETKEY A$            :REM WAIT FOR KEYPRESS
70 SCREEN CLOSE
```



DATA

Format: **DATA** [constant [, constant ...]]

Usage: Defines constants which can be read by **READ** statements in a program.

Numbers and strings are allowed, but expressions are not. Items are separated by commas. Strings containing commas, colons or spaces must be placed in quotes.

RUN initialises the data pointer to the first item of the first **DATA** statement and advances it for every read item. It is the programmer's responsibility that the type of the constant and the variable in the **READ** statement match. Empty items with no constant between commas are allowed and will be interpreted as zero for numeric variables and an empty string for string variables.

RESTORE may be used to set the data pointer to a specific line for subsequent reads.

Remarks: It is good programming practice to put large amounts of **DATA** statements at the end of the program, so they don't slow down the search for line numbers after **GOTO**, and other statements with line number targets.

Example: Using **DATA**

```
1 REM DATA
10 READ NA$, VE
20 READ N% : FOR I=2 TO N% : READ GL(I) : NEXT I
30 PRINT "PROGRAM:";NA$;"  VERSION:";VE
40 PRINT "N-POINT GAUSSLEGENDRE FACTORS E1":
50 FOR I=2 TO N%:PRINT I;GL(I):NEXT I
60 END
80 DATA "MEGA65",1.1
90 DATA 5,0.5120,0.3573,0.2760,0.2252

RUN
PROGRAM:MEGA65  VERSION: 1.1
N-POINT GAUSSLEGENDRE FACTORS E1
 2  0.512
 3  0.3573
 4  0.276
 5  0.2252
```

DCLEAR

Format: **DCLEAR** [**,D** drive] [**,U** unit]

Usage: Sends an initialise command to the specified unit and drive.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

The DOS of the disk drive will close all open files, clear all channels, free buffers and re-read the BAM. All open channels on the computer will also be closed.

Examples: Using **DCLEAR**

```
DCLEAR
DCLEAR U9
DCLEAR D0, U9
```

DCLOSE

Format: **DCLOSE** [**U** unit]
DCLOSE # channel

Usage: Closes a single file or all files for the specified unit.

channel number, which was given to a previous call to commands such as **APPEND**, **DOPEN**, or **OPEN**.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

DCLOSE is used either with a channel argument or a unit number, but never both.

Remarks: It is important to close all open files before a program ends. Otherwise buffers will not be freed and even worse, open files that have been written to may be incomplete (commonly called splat files), and no longer usable.

Examples: Using **DCLOSE**

```
DCLOSE#2 :REM CLOSE FILE ASSIGNED TO CHANNEL 2
DCLOSE U9:REM CLOSE ALL FILES OPEN ON UNIT 9
```

DEC

Format: **DEC**(string expression)

Returns: The decimal value of a hexadecimal string.

The argument range is “0” to “FFFFFFFF”. **DEC()** ignores everything after the first non-hex digit or the eighth character.

Remarks: Allowed digits in uppercase/graphics mode are 0 – 9 and A – F (`0123456789ABCDEF`) and in lowercase/uppercase mode are 0 – 9 and a – f (`0123456789abcdef`).

Example: Using **DEC**

```
PRINT DEC("D000")
53248

POKE DEC("600"),255
```

DECBIN

Format: **DECBIN(**string expression**)**

Returns: The decimal value of a binary string.

The argument range is “0” to “1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
DECBIN() ignores everything after the first non-binary digit or the 32nd character.

Example: Using **DECBIN**

```
PRINT DECBIN("1101000000000000")
53248
```

DEF FN

Format: **DEF FN** name**(**real variable**)** = [expression]

Usage: Defines a single statement user function with one argument of type real, that returns a real value when evaluated.

The definition must be executed before the function can be used in expressions. The argument is a dummy variable, which will be replaced by the argument when the function is used.

Remarks: The function argument is not a real variable and will not overwrite a variable with that name. It only represents the argument value within the function definition.

Example: Using **DEF FN**

```
10 PD = π / 180
20 DEF FN CD(X)= COS(X*PD): REM COS FOR DEGREES
30 DEF FN SD(X)= SIN(X*PD): REM SIN FOR DEGREES
40 FOR D=0 TO 360 STEP 90
50 PRINT USING "####";D
60 PRINT USING " ##.##";FNCD(D);
70 PRINT USING " ##.##";FNSD(D)
80 NEXT D
RUN
  0  1.00  0.00
 90  0.00  1.00
180 -1.00  0.00
270  0.00 -1.00
360  1.00  0.00
```

DELETE

Format: **DELETE** [line range]
DELETE filename [**,D** drive] [**,U** unit] [**,R**]

Usage: The first form deletes a range of lines from the BASIC program. The second form deletes one or more files from a disk.

line range consists of the first and last line to delete, or a single line number. If the first number is omitted, the first BASIC line is assumed. The second number in the range specifier defaults to the last BASIC line.

filename is either a quoted string, for example: `"SAFE""` or a string expression in brackets, for example: `(FS$)`

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

R Recover a previously deleted file. This will only work if there were no write operations between deletion and recovery, which may have altered the contents of the file.

Remarks: **DELETE filename** is a synonym of **SCRATCH filename** and **ERASE filename**.

Examples: Using **DELETE**

```
DELETE 100      :REM DELETE LINE 100
DELETE 240-350  :REM DELETE ALL LINES FROM 240 TO 350
DELETE 500-     :REM DELETE FROM 500 TO END
DELETE -70      :REM DELETE FROM START TO 70

DELETE "DRM",U9 :REM DELETE FILE DRM ON UNIT 9
DELETE "*=SEQ"  :REM DELETE ALL SEQUENTIAL FILES
DELETE "R*=PRG" :REM DELETE PROGRAM FILES STARTING WITH 'R'
```

DIM

Format: **DIM** name(limits) [**,** name(limits) ...]

Usage: Declares the shape, bounds and the type of a BASIC array.

As a declaration statement, it must be executed only once and before any usage of the declared arrays. An array can have one or more dimensions. One dimensional arrays are often called vectors while two or more dimensions define a matrix. The lower bound of a dimension is always zero, while the upper bound is as declared. The rules for variable names apply for array names as well. You can create byte arrays, integer arrays, real arrays and string arrays. It is legal to use the same identifier for scalar variables and array variables. The left parenthesis after the name identifies array names.

Remarks: Byte arrays consume one byte per element, integer arrays two bytes, real arrays five bytes and string arrays three bytes for the string descriptor plus the length of the string itself.
If an array identifier is used without being previously declared, an implicit declaration of an one dimensional array with limit of 10 is performed.

Example: Using **DIM**

```
1 REM DIM
10 DIM A%(8)    : REM ARRAY OF 9 ELEMENTS
20 DIM XX(2,3)  : REM ARRAY OF 3X4 = 12 ELEMENTS
30 FOR I=0 TO 8 : A%(I)=PEEK(256+I) : PRINT A%(I);: NEXT:PRINT
40 FOR I=0 TO 2 : FOR J=0 TO 3 : READ XX(I,J):PRINT XX(I,J);: NEXT J,I
50 END
60 DATA 1,-2,3,-4,5,-6,7,-8,9,-10,11,-12

RUN
 45  52  50  0  0  0  0  0  0
 1 -2  3 -4  5 -6  7 -8  9 -10  11 -12
```

DIR

Format: **DIR** [filepattern] [**,W**] [**,P**] [**,R**] [**,D** drive] [**,U** unit]
DIRECTORY [filepattern] [**,W**] [**,P**] [**,R**] [**,D** drive] [**,U** unit]
$ [filepattern] [**,W**] [**,R**] [**,D** drive] [**,U** unit]
DIR U12 [**,P**]

Usage: Prints a file directory/catalog of the specified disk.

The **W** (Wide) parameter lists the directory three columns wide on the screen and pauses after the screen has been filled with a page (63 directory entries). Pressing any key displays the next page.

The **P** (Pagination) parameter lists the directory one column wide, and pauses for each screenful of output. Press the Q key to interrupt the listing at the current page. Press any other key to display the next page.

The **R** (Recoverable) parameter includes files in the directory, which are flagged as deleted but are still recoverable.

filepattern is either a quoted string, for example: "DA*" or a string expression in brackets, e.g. (DI$)

The **U12** argument lists the contents of the SD card. It can be used with the **P** argument for a paginated display. It does not support other arguments.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **DIR** is a synonym of **CATALOG** and **DIRECTORY**, and produces the same listing. The **filepattern** can be used to filter the listing. The wildcard characters * and **?** may be used. Adding **,T=** to the pattern string, with **T** specifying a filetype of **P**, **S**, **U** or **R** (for **P**RG, **S**EQ, **U**SR, **R**EL) filters the output to that filetype.

The shortcut symbol **$** can only be used in direct mode.

Examples: Using **DIR**

```
DIR
0 "BLACK SMURF      " BS 2A
508  "STORY PHOBOS"     SEQ
27   "C8096"            PRG
25   "C128"             PRG
104 BLOCKS FREE.
```

For a **DIR** listing with the **w**ide parameter, please refer to the example under **CATALOG** on page 109.

DISK

Format: **DISK** command [**,U** unit]
@ command [**,U** unit]

Usage: Sends a command string to the specified disk unit.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

command is a string expression.

Remarks: The command string is interpreted by the disk unit and must be compatible to the used DOS version. Read the disk drive manual for possible commands.

Using **DISK** with no parameters prints the disk status.

The shortcut key @ can only be used in direct mode.

Examples: Using **DISK**

```
DISK "I0"   :REM INITIALISE DISK IN DRIVE 0
DISK "U0>9" :REM CHANGE UNIT# TO 9
```

DLOAD

Format: **DLOAD** filename [**,D** drive] [**,U** unit]
DLOAD "$[pattern=type]" [**,D** drive] [**,U** unit]
DLOAD "$$[pattern=type]" [**,D** drive] [**,U** unit]

Usage: The first form loads a file of type PRG into memory reserved for BASIC programs.

The second form loads a directory into memory, which can then be viewed with **LIST**. It is structured like a BASIC program, but file sizes are displayed instead of line numbers.

The third form is similar to the second one, but the files are numbered. This listing can be scrolled like a BASIC program with the keys **F9** or **F11**, edited, listed, saved or printed.

A filter can be applied by specifying a pattern or a pattern and a type. The asterisk matches the rest of the name, while the ? matches any single character. The type specifier can be a character of (P,S,U,R), that is Program, Sequential, User, or Relative file.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: The load address that is stored in the first two bytes of the PRG file is ignored. The program is always loaded into BASIC memory. This enables loading of BASIC programs that were saved on other computers with different memory configurations. After loading, the program is re-linked and ready to be **RUN** or edited.

It is possible to use **DLOAD** in a running program. This is called overlaying, or chaining. If you do this, then the newly loaded program replaces the current one, and the execution starts automatically on the first line of the new program. Variables, arrays and strings from the current run are preserved and can also be used by the newly loaded program.

Every **DLOAD**, of either a program or a directory listing, will replace a program that is currently in memory.

Examples: Using **DLOAD**

```
DLOAD "APOCALYPSE"
DLOAD "MEGA TOOLS",U9
DLOAD (FI$),U(UN%)

DLOAD "$"          :REM LOAD WHOLE DIRECTORY - WITH FILE SIZES
DLOAD "$$"         :REM LOAD WHOLE DIRECTORY - SCROLLABLE
DLOAD "$$X*=P"     :REM DIRECTOY WITH PRG FILES STARTING with 'X'
```

DMA

Format: **DMA** command [, length, source address, source bank, target address, target bank [, sub]]

Usage: **DMA** ("Direct Memory Access") is obsolete, and has been replaced by **EDMA**.

command The lower two bits control the function: 0: copy, 1: mix, 2: swap, 3: fill. Note that only copy and fill are implemented in the MEGA65 DMAcontroller at the time of writing. Other DMAgic command bits can also be set, for example, to allow copying data in the reverse direction, or holding the source or destination address.

length number of bytes (in the range 0 to 65535). NOTE: Specifying a length of 0 will be interpreted as a length of 65536 (exactly 64 kilobytes).

source address 16-bit address of read area or fill byte

source bank bank number for source (ignored for fill mode)

target 16-bit address of write area

target bank bank number for target

sub sub command

Remarks: **DMA** has access to the lower 1MB address range organised in 16 banks of 64 K. To avoid this limitation, use **EDMA**, which has access to the full 256MB address range.

Examples: A sequence of **DMA** calls to demonstrate fast screen drawing operations

```
DMA 0, 80*25, 2048, 0, 0, 4  :REM SAVE SCREEN TO $00000 BANK 4
DMA 3, 80*25, 32, 0, 2048, 0 :REM FILL SCREEN WITH BLANKS
DMA 0, 80*25, 0, 4, 2048, 0  :REM RESTORE SCREEN FROM $00000 BANK 4
DMA 2, 80, 2048, 0, 2048+80, 0 :REM SWAP CONTENTS OF LINE 1 & 2 OF SCREEN
```

DMODE

Format: **DMODE** jam, complement, stencil, style, thick

Usage: Bitmap graphics: sets "display mode" parameters of the graphics context, which is used by drawing commands.

Mode	Values
jam	0 - 1
complement	0 - 1
stencil	0 - 1
style	0 - 3
thick	1 - 8

DO

Format: **DO** ... **LOOP**
DO [<**UNTIL** | **WHILE**> logical expression]
. . . statements [**EXIT**]
LOOP [<**UNTIL** | **WHILE**> logical expression]

Usage: **DO** and **LOOP** define the start of a BASIC loop.

Using **DO** and **LOOP** alone without any modifiers creates an infinite loop, which can only be exited by the **EXIT** statement. The loop can be controlled by adding **UNTIL** or **WHILE** after the **DO** or **LOOP**.

Remarks: **DO** loops may be nested. An **EXIT** statement only exits the current loop.

Examples: Using **DO** and **LOOP**

```
10 PW$="":DO
20 GET A$:PW$=PW$+A$
30 LOOP UNTIL LEN(PW$)>7 OR A$=CHR$(13)

10 DO : REM WAIT FOR USER DECISION
20 GET A$
30 LOOP UNTIL A$="Y" OR A$="N" OR A$="y" OR A$="n"

10 DO WHILE ABS(EPS) > 0.001
20 GOSUB 2000 : REM ITERATION SUBROUTINE
30 LOOP

10 I%=0 : REM INTEGER LOOP 1-100
20 DO: I%=I%+1
30 LOOP WHILE I% < 101
```

DOPEN

Format: **DOPEN#** channel**,** filename [**,L** [reclen]] [**,W**] [**,D** drive] [**,U** unit]

Usage: Opens a file for reading or writing.

channel number, where:

- **1 <= channel <= 127** line terminator is CR.
- **128 <= channel <= 255** line terminator is CR LF.

L indicates, that the file is a relative file, which is opened for read-/write, as well as random access.

The **reclen** record length is mandatory for creating relative files. For existing relative files, **reclen** is used as a safety check, if given.

W opens a file for write access. The file must not exist.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **DOPEN#** may be used to open all file types. The sequential file type **SEQ** is default. The relative file type **REL** is chosen by using the **L** parameter. Other file types must be specified in the filename, e.g. by adding ",P" to the filename for **PRG** files or ",U" for **USR** files.

If the first character of the filename is an at sign '@', it is interpreted as a "save and replace" operation. It is not recommended to use this option on 1541 and 1571 drives, as they contain a "save and replace bug" in their DOS.

Examples: Using **DOPEN**

```
DOPEN#5,"DATA",U9
DOPEN#130,(DD$),U(UN%)
DOPEN#3,"USER FILE,U"
DOPEN#2,"DATA BASE",L240
DOPEN#4,"MYPROG,P" : REM OPEN PRG FILE
```

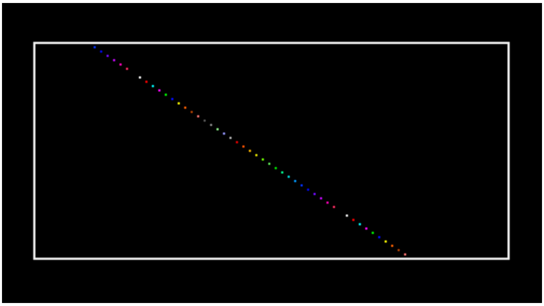
DOT

Format: **DOT** x, y [,colour]

Usage: Bitmap graphics: draws a pixel at screen coordinates x and y. The optional third parameter defines the colour to be used. If not specified, the current pen colour will be used.

Example: Using **DOT**:

```
10 SCREEN 320,200,5
20 BOX 50,50,270,150
30 VIEWPORT 50,50,220,100
40 FORI=0TO127
50 DOT I+I+I,I+I,I
60 NEXT
70 GETKEY A
80 SCREEN CLOSE
```



DPAT

Format: **DPAT** type [**,** number**,** pattern ...]

Usage: Bitmap graphics: sets the drawing pattern of the graphics context for drawing commands.

There a four predefined pattern types, that can be selected by specifying the type number (1, 2, 3, or 4) as a single parameter.

A value of zero for the type number indicates a user defined pattern. This pattern can be set by using a bit string that consists of either 8, 16, 24, or 32 bits. The number of used pattern bytes is given as the second parameter. It defines how many pattern bytes (1, 2, 3, or 4) follow.

- **Type** 0 – 4
- **Number** number of following pattern bytes (1 – 4)
- **Pattern** pattern bytes

DS

Format: **DS**

Usage: The status of the last disk operation.

This is a volatile variable. Each use triggers the reading of the disk status from the current disk device in usage.

DS is coupled to the string variable **DS$** which is updated at the same time.

Reading the disk status from a disk device automatically clears any error status on that device, so subsequent reads will return 0, if no other activity has since occurred.

Remarks: **DS** is a reserved system variable.

Example: Using **DS**

```
100 DOPEN#1,"DATA"
110 IF DS<>0 THEN PRINT"COULD NOT OPEN FILE DATA":STOP
```

DS$

Format: **DS$**

Usage: The status of the last disk operation in text form of the format: Code,Message,Track,Sector.

DS$ is coupled to the numeric variable **DS**. It is updated when **DS** is used. DS$ is set to `00,OK,00,00` if there was no error, otherwise it is set to a DOS error message (listed in the disk drive manuals).

Remarks: **DS$** is a reserved system variable.

Example: Using **DS$**

```
100 DOPEN#1,"DATA"
110 IF DS<>0 THEN PRINT DS$:STOP
```

DSAVE

Format: **DSAVE** filename [**,D** drive] [**,U** unit]

Usage: Saves the BASIC program in memory to a file of type **PRG**.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`. The maximum length of the filename is 16 characters. If the first character of the filename is an at sign '`@`' it is interpreted as a "save and replace" operation. It is not recommended to use this option on 1541 and 1571 drives, as they contain a "save and replace bug" in their DOS.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **DVERIFY** can be used after **DSAVE** to check if the saved program on disk is identical to the program in memory.

Example: Using **DSAVE**

```
DSAVE "ADVENTURE"
DSAVE "ZORK-I",U9
DSAVE "DUNGEON",D1,U10
```

DT$

Format: **DT$**

Usage: The current date, as a string.

The date value is updated from RTC (Real-Time Clock). The string **DT$** is formatted as: "DD-MON-YYYY", for example: "04-APR-2021".

Remarks: **DT$** is a reserved system variable. For more information on how to set the Real-Time Clock, refer to the **MEGA65 Book**.

Example: Using **DT$**

```
100 PRINT "TODAY IS: ";DT$
```

DVERIFY

Format: **DVERIFY** filename [**,D** drive] [**,U** unit]

Usage: Verifies that the BASIC program in memory is equivalent to a file of type **PRG**.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **DVERIFY** can only test for equality. It gives no information about the number or position of different valued bytes. **DVERIFY** exits either with the message `OK` or with `VERIFY ERROR`.

Example: Using **DVERIFY**

```
DVERIFY "ADVENTURE"
DVERIFY "ZORK-I",U9
DVERIFY "DUNGEON",D1,U10
```

EDIT

Format: **EDIT** <**ON** | **OFF**>

Usage: Enables or disables the text editing mode of the screen editor.

EDIT ON enables text editing mode. In this mode, you can create, edit, save, and load files of type SEQ as text files using the same line editor that you use to write BASIC programs. In this mode:

- The prompt appears as `OK`, instead of `READY.`
- The editor does no tokenising/parsing. All text entered after a linenumber remains pure text, BASIC keywords such as **FOR** and **GOTO** are not converted to BASIC tokens, as they are whilst in program mode.
- The line numbers are only used for text organisation, sorting, deleting, listing, etc.
- When the text is saved to file with **DSAVE**, a sequential file (type **SEQ**) is written, not a program (**PRG**) file. Line numbers are *not* written to the file.
- **DLOAD** in text mode can load only sequential files. Line numbers are automatically generated for editing purposes.
- Text mode applies to lines entered with line numbers only. Lines with no line number are executed as BASIC commands, as usual.

EDIT OFF disables text editing mode and returns to BASIC program editing mode. The MEGA65 starts in BASIC program editing mode.

Sequential files created with the text editor can be displayed (without loading them) on the screen by using **TYPE <filename>**.

Example: Using **EDIT**

```
ready.
edit on

ok.
100 This is a simple text editor.
dsave "example"

ok.
new

ok.
catalog

0 "demoempty        " 00 3d
1 "example"          seq
3159 blocks free

ok.
type "example"
This is a simple text editor.

ok.
dload "example"

loading

ok.
list

1000 This is a simple text editor.

ok.
```

EDMA

Format: **EDMA** command, length, source, target

Usage: Copies or updates a large amount of memory quickly.

EDMA ("Extended Direct Memory Access") is the fastest method to manipulate memory areas using the DMA controller. Please refer to the **MEGA65 Book** for more details on EDMA.

command 0: copy, 1: mix, 2: swap, 3: fill.

Because this two bits of the command share the same register with other bits you can for example use bit 5 to reverse loop operation. This is also working in overlapping memory regions for source and target. Please see the example below.

length number of bytes (in the range 0 to 65535). NOTE: Specifying a length of 0 will be interpreted as a length of 65536 (exactly 64 kilobytes).

source 28-bit address of read area or fill byte.

target 28-bit address of write area.

Remarks: **EDMA** can access the entire 256MB address range, using up to 28 bits for the addresses of the source and target.

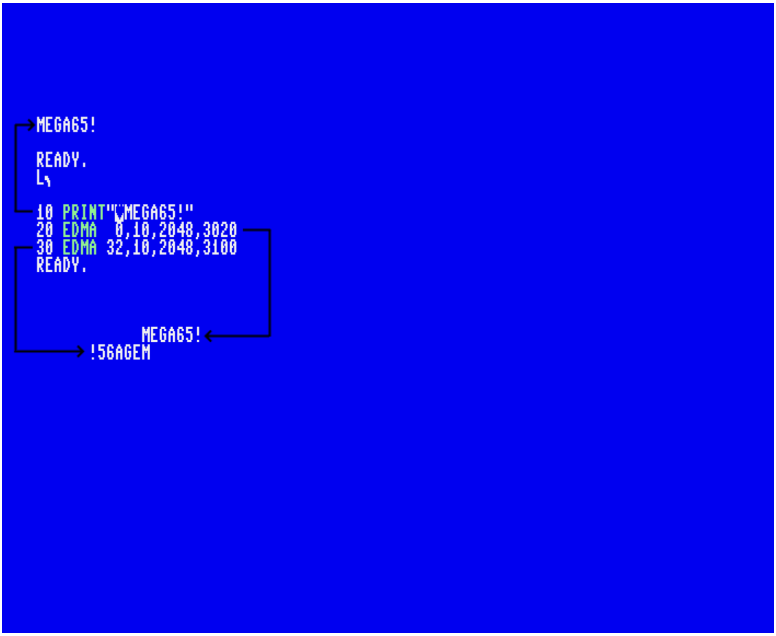
Examples: Using **EDMA**

```
EDMA 0, $800, $F700, $8000000 :REM COPY SCALAR VARIABLES TO ATTIC RAM
EDMA 3, 80*25, 32, 2048       :REM FILL SCREEN WITH BLANKS
EDMA 0, 80*25, 2048, $8000800 :REM COPY SCREEN TO ATTIC RAM
```

By adding 32 (bit 5) to the command parameter, the DMA operation can be performed in reverse order:

```
10 PRINT "♥MEGA65!"
20 EDMA  0,10,2048,3020  : REM 2048 IS BEGINNING OF SCREEN RAM
30 EDMA 32,10,2048,3100  : REM 3020 AND 3100 ARE THE LOWER PART OF THE SCREEN
```

Listing and output of the last example:



EL

Format: **EL**

Usage: The line number where the most recent BASIC error occurred, or the value -1 if there was no error.

Remarks: **EL** is a reserved system variable.

This variable is typically used in a **TRAP** routine, where the error line is taken from **EL**.

Example: Using **EL**

```
 10 TRAP 100
 20 PRINT SQR(-1)     :REM PROVOKE ERROR
 30 PRINT "AT LINE 30":REM HERE TO RESUME
 40 END
100 IF ER>0 THEN PRINT ERR$(ER);" ERROR"
110 PRINT " IN LINE";EL
120 RESUME NEXT       :REM RESUME AFTER ERROR
```

ELLIPSE

Format: **ELLIPSE** xc, yc, xr, yr [, flags , start, stop]

Usage: Bitmap graphics: draws an ellipse.

xc is the x coordinate of the centre in pixels

yc is the y coordinate of the centre in pixels

xr is the x radius of the ellipse in pixels

yr is the y radius of the ellipse in pixels

flags control filling, arcs and orientation of the zero radian (combs flag named after **retroCombs**). Default setting (zero) is: Don't fill, draw legs, start drawing at 3 'o clock.

Bit	Name	Value	Action if set
0	fill	1	Fill ellipse or arc with the current pen colour
1	legs	2	Suppress drawing of the legs of an arc
2	combs	4	Drawing (0 degree) starts at 12 'o clock

The units for the start- and stop-angle are degrees in the range of 0 to 360. The 0 radian starts at 3 o' clock and moves clockwise. The combs-flag shifts the 0 radian and the start position to the 12 'o clock position.

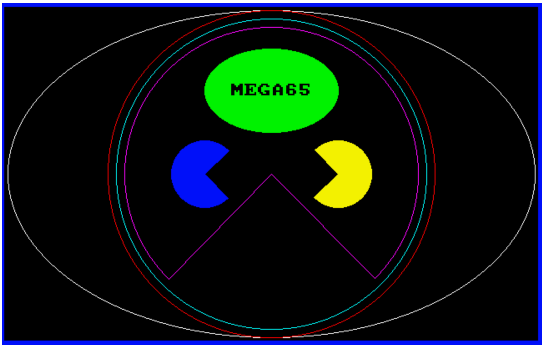
start start angle for drawing an elliptic arc.

stop stop angle for drawing an elliptic arc.

Remarks: **ELLIPSE** is used to draw ellipses on screens at various resolutions. If a full ellipse is to be drawn, start and stop should be either omissed or set both to zero (not 0 and 360). Drawing and filling of full ellipses is much faster, than using elliptic arcs.

Example: Using **ELLIPSE**

```
100 S%=2:D%=3:W%=320*S%:H%=200*S%  :REM SCREEN SETTINGS
110 CX%=W%/2:CY%=H%/2              :REM CENTRE AND RADII
120 RX%=W%/2:RY%=H%/2
130 SCREEN W%,H%,D%                :REM OPEN SCREEN
140 ELLIPSE CX%,CY%,CX%-4,CY%-4
150 PEN2:CIRCLE CX%,CY%,RY%-4,2
160 PEN3:CIRCLE CX%,CY%,RY%-14,2
170 PEN4:CIRCLE CX%,CY%,RY%-24,0,135,45
180 PEN5:ELLIPSE CX%,CY%/2,RX%/4,RY%/4,1
190 PEN6:CIRCLE 120*S%,CY%,40,1,45,315
200 PEN7:CIRCLE 200*S%,CY%,40,1,225,135
210 PEN0:CHAR 34,CY%/2-8,2,2,2,"MEGA65",$3D000
220 GETKEY A$                      :REM WAIT FOR ANY KEY
230 SCREEN CLOSE                   :REM CLOSE GRAPHICS SCREEN
```



ELSE

Format: **IF** expression **THEN** true clause [**:ELSE** false clause]

Usage: **ELSE** is an optional part of an **IF** statement.

expression a logical or numeric expression. A numeric expression is evaluated as **FALSE** if the value is zero and **TRUE** for any non-zero value.

true clause one or more statements starting directly after **THEN** on the same line. A line number after **THEN** performs a **GOTO** to that line instead.

false clause one or more statements starting directly after **ELSE** on the same line. A linenumber after **ELSE** performs a **GOTO** to that line instead.

Remarks: There must be a colon before **ELSE**. There cannot be a colon or end-of-line after **ELSE**.

The standard **IF ... THEN ... ELSE** structure is restricted to a single line. But the **true clause** and **false clause** may be expanded to several lines using a compound statement surrounded with **BEGIN** and **BEND**.

When the **true clause** does not use **BEGIN** and **BEND**, **ELSE** must be on the same line as **IF**.

Example: Using **ELSE**

```
100 REM ELSE
110 RED$=CHR$(28):BLACK$=CHR$(144):WHITE$=CHR$(5)
120 INPUT "ENTER A NUMBER";V
130 IF V<0 THENPRINT RED$;:ELSEPRINT BLACK$;
140 PRINT V : REM PRINT NEGATIVE NUMBERS IN RED
150 PRINT WHITE$
160 INPUT "END PROGRAM:(Y/N)";A$
170 IF A$="Y" THENEND
180 IF A$="N" THEN120:ELSE160
```

Using **ELSE** with **BEGIN** and **BEND**.

```
100 A = 0 : GOSUB 200
110 A = 1 : GOSUB 200
120 END
200 IF A = 0 THEN BEGIN
210 PRINT "HELLO"
220 BEND : ELSE BEGIN
230 PRINT "GOODBYE"
240 BEND
250 RETURN
```

END

Format: **END**

Usage: Ends the execution of the BASIC program.

The `READY.` prompt appears and the computer goes into direct mode waiting for keyboard input.

Remarks: **END** does **not** clear channels nor close files. Variable definitions are still valid after **END**. The program may be continued with the **CONT** statement. After executing the last line of a program, **END** is executed automatically.

Example: Using **END**

```
10 IF V < 0 THEN END : REM NEGATIVE NUMBERS END THE PROGRAM
20 PRINT V
```

ENVELOPE

Format: **ENVELOPE** n [{, attack, decay, sustain, release, waveform, pw}]

Usage: Sets the parameters for the synthesis of a musical instrument for use with **PLAY**.

n envelope slot (0 – 9).

attack attack rate (0 – 15).

decay decay rate (0 – 15).

sustain sustain rate (0 – 15).

release release rate (0 – 15).

waveform 0: triangle, 1: sawtooth, 2: square/pulse, 3: noise, 4: ring modulation.

pw pulse width (0 – 4095) for waveform.

There are 10 slots for storing instrument parameters, preset with the following default values:

n	A	D	S	R	WF	PW	Instrument
0	0	9	0	0	2	1536	Piano
1	12	0	12	0	1		Accordion
2	0	0	15	0	0		Calliope
3	0	5	5	0	3		Drum
4	9	4	4	0	0		Flute
5	0	9	2	1	1		Guitar
6	0	9	0	0	2	512	Harpsichord
7	0	9	9	0	2	2048	Organ
8	8	9	4	1	2	512	Trumpet
9	0	9	0	0	0		Xylophone

Example: Using **ENVELOPE**

```
10 ENVELOPE 9,10,5,10,5,2,4000
20 VOL 9,9
30 TEMPO 30
40 PLAY "T904Q CDEFGAB U3T8 CDEFGAB L","T503Q H CGEQG T7 HCGEQG L"
```

ER

Format: **ER**

Usage: The number of the most recent BASIC error that has occurred, or -1 if there was no error.

Remarks: **ER** is a reserved system variable.

This variable is typically used in a **TRAP** routine, where the error number is taken from **ER**.

Example: Using **ER**

```
 10 TRAP 100
 20 PRINT SQR(-1)     :REM PROVOKE ERROR
 30 PRINT "AT LINE 30":REM HERE TO RESUME
 40 END
100 IF ER>0 THEN PRINT ERR$(ER);" ERROR"
110 PRINT " IN LINE";EL
120 RESUME NEXT       :REM RESUME AFTER ERROR
```

ERASE

Format: **ERASE** filename [**,D** drive] [**,U** unit] [**,R**]

Usage: Erases (deletes) a disk file.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

R Recover a previously erased file. This will only work if there were no write operations between erasing and recovery, which may have altered the contents of the disk.

Remarks: **ERASE filename** is a synonym of **SCRATCH filename** and **DELETE filename**.

In direct mode, the success and the number of erased files is printed. The second to last number from the message contains the number of successfully erased files.

Examples: Using **ERASE**

```
ERASE "DRM",U9 :REM ERASE FILE DRM ON UNIT 9
01, FILES SCRATCHED,01,00
ERASE "OLD*"   :REM ERASE ALL FILES BEGINNING WITH "OLD"
01, FILES SCRATCHED,04,00
ERASE "R*=PRG" :REM ERASE PROGRAM FILES STARTING WITH 'R'
01, FILES SCRATCHED,09,00
```

ERR$

Format: **ERR$**(number)

Returns: The string description of a given BASIC error number.

number a BASIC error number (1 – 41)

This function is typically used in a **TRAP** routine, where the error number is taken from the reserved variable **ER**.

Remarks: Arguments out of range (1 – 41) will produce an ILLEGAL QUANTITY error.

Example: Using **ERR$**

```
 10 TRAP 100
 20 PRINT SQR(-1)     :REM PROVOKE ERROR
 30 PRINT "AT LINE 30":REM HERE TO RESUME
 40 END
100 IF ER>0 THEN PRINT ERR$(ER);" ERROR"
110 PRINT " IN LINE";EL
120 RESUME NEXT       :REM RESUME AFTER ERROR
```

EXIT

Format: **EXIT**

Usage: Exits the current **DO .. LOOP** and continues execution at the first statement after **LOOP**.

Remarks: In nested loops, **EXIT** exits only the current loop, and continues execution in an outer loop (if there is one).

Example: Using **EXIT**

```
1 REM EXIT
10 OPEN 2,8,0,"$"             : REM OPEN CATALOG
15 IF DS THEN PRINT DS$: STOP: REM CANT READ
20 GET#2,D$,D$                : REM DISCARD LOAD ADDRESS
25 DO                         : REM LINE LOOP
30   GET#2,D$,D$              : REM DISCARD LINE LINK
35   IF ST THEN EXIT          : REM END-OF-FILE
40   GET#2,LO,HI              : REM FILE SIZE BYTES
45   S=LO + 256 * HI          : REM FILE SIZE
50   LINE INPUT#2, F$         : REM FILE NAME
55   PRINT S;F$               : REM PRINT FILE ENTRY
60 LOOP
65 CLOSE 2
```

EXP

Format: **EXP**(numeric expression)

Returns: The value of the mathematical constant Euler's number (**2.71828183**) raised to the power of the argument.

Remarks: An argument greater than 88 produces an `OVERFLOW ERROR`.

Examples: Using **EXP**

```
PRINT EXP(1)
 2.71828183

PRINT EXP(0)
 1

PRINT EXP(LOG(2))
 2
```

FAST

Format: **FAST** [speed]

Usage: Sets CPU clock speed to 1MHz, 3.5MHz or 40MHz.

speed CPU clock speed where:

- **1** sets CPU to 1MHz.
- **3** sets CPU to 3MHz.
- Anything other than **1** or **3** sets the CPU to 40MHz.

Remarks: Although it's possible to call **FAST** with any real number, the precision part (the decimal point and any digits after it), will be ignored.

FAST is a synonym of **SPEED**.

FAST has no effect if `POKE 0,65` has previously been used to set the CPU to 40MHz.

Example: Using **FAST**

```
10 FAST     :REM SET SPEED TO MAXIMUM (40 MHZ)
20 FAST 1   :REM SET SPEED TO 1 MHZ
30 FAST 3   :REM SET SPEED TO 3.5 MHZ
40 FAST 3.5 :REM SET SPEED TO 3.5 MHZ
```

FGOSUB

Format: **FGOSUB** numeric expression

Usage: Evaluates the given numeric expression, then calls (**GOSUB**s) the subroutine at the resulting line number.

Warning: Take care when using **RENUMBER** to change the line numbers of your program that any **FGOSUB** statements still use the intended numbers.

Example: Using **FGOSUB**:

```
 10 INPUT "WHICH SUBROUTINE TO EXECUTE 100,200,300";LI
 20 FGOSUB LI     :REM HOPEFULLY THIS LINE # EXISTS
 30 GOTO 10       :REM REPEAT
100 PRINT "AT LINE 100":RETURN
200 PRINT "AT LINE 200":RETURN
300 PRINT "AT LINE 300":RETURN
```

FGOTO

Format: **FGOTO** numeric expression

Usage: Evaluates the given numeric expression, then jumps (**GO**es**TO**) to the resulting line number.

Warning: Take care when using **RENUMBER** to change the line numbers of your program that any **FGOTO** statements still use the intended numbers.

Example: Using **FGOTO**:

```
 10 INPUT "WHICH LINE # TO EXECUTE 100,200,300";LI
 20 FGOTO LI     :REM HOPEFULLY THIS LINE # EXISTS
 30 END
100 PRINT "AT LINE 100":END
200 PRINT "AT LINE 200":END
300 PRINT "AT LINE 300":END
```

FILTER

Format: **FILTER** sid [{, freq, lp, bp, hp, res}]

Usage: Sets the parameters for a SID sound filter.

sid 1: right SID, 2: left SID

freq filter cut off frequency (0 - 2047)

lp low pass filter (0: off, 1: on)

bp band pass filter (0: off, 1: on)

hp high pass filter (0: off, 1: on)

resonance resonance (0 - 15)

Remarks: Missing parameters keep their current value. The effective filter is the sum of of all filter settings. This enables band reject and notch effects.

Example: Using **FILTER**

```
10 PLAY "T7X1O3P9C"
15 SLEEP 0.02
20 PRINT "LOW PASS SWEEP" :L=1:B=0:H=0:GOSUB 100
30 PRINT "BAND PASS SWEEP":L=0:B=1:H=0:GOSUB 100
40 PRINT "HIGH PASS SWEEP":L=0:B=0:H=1:GOSUB 100
50 GOTO 20
100 REM *** SWEEP ***
110 FOR F = 50 TO 1950 STEP 50
120 IF F >= 1000 THEN FF = 2000-F : ELSE FF = F
130 FILTER 1,FF,L,B,H,15
140 PLAY "X1"
150 SLEEP 0.02
160 NEXT F
170 RETURN
```

FIND

Format: **FIND /**string**/** [**,** line range]
FIND "string**"** [**,** line range]

Usage: Searches the BASIC program that is currently in memory for all instances of a string.

It searches a given line range (if specified), otherwise the entire BASIC program is searched.

At each occurrence of the "find string" the line is listed with the string highlighted.

NO SCROLL can be used to pause the output.

Remarks: Almost any character that is not part of the string, including letters and punctuation, can be used instead of the slash **/**.

Using double quotes **"** as a delimiter has a special effect: The search text is not tokenised. **FIND "FOR"** will search for the three letters F, O, and R, not the BASIC keyword **FOR**. Therefore, it can find the word **FOR** in string constants or REM statements, but not in program code.

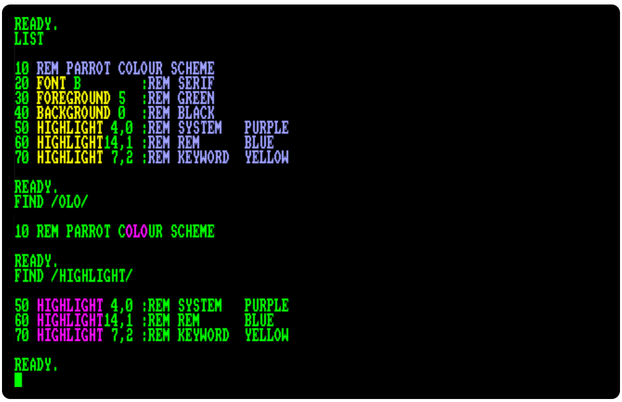
On the other hand, **FIND /FOR/** will find all occurrences of the BASIC keyword, but not the text "FOR" in strings.

Partial keywords cannot be searched. For example, **FIND /LOO/** will not find the keyword **LOOP**.

Due to how BASIC is parsed, finding the **REM** and **DATA** keywords requires using the colon as the delimiter: **FIND :REM TODO:** This does not work with the **CHANGE** command.

FIND is an editor command that can only be used in direct mode.

Example: Using **FIND**



FN

Format: **FN** name(numeric expression)

Usage: **FN** functions are user-defined functions, that accept a numeric expression as an argument and return a real value. They must first be defined with **DEF FN** before being used.

Example: Using **FN**

```
10 PD = π / 180
20 DEF FN CD(X)= COS(X*PD): REM COS FOR DEGREES
30 DEF FN SD(X)= SIN(X*PD): REM SIN FOR DEGREES
40 FOR D=0 TO 360 STEP 90
50 PRINT USING "####";D
60 PRINT USING " ##.##";FNCD(D);
70 PRINT USING " ##.##";FNSD(D)
80 NEXT D
RUN
  0  1.00  0.00
 90  0.00  1.00
180 -1.00  0.00
270  0.00 -1.00
360  1.00  0.00
```

FONT

Format: **FONT** <**A** | **B** | **C**>

Usage: Updates all characters to the given built-in font.

FONT A is the PETSCII font with several lowercase characters replaced with ASCII punctuation.

FONT B is an alternate appearance of **FONT A**.

FONT C is the PETSCII font. This is the default when the MEGA65 is first switched on.

This resets any changes made by the **CHARDEF** command.

The ASCII symbols of fonts **A** and **B** are typed by pressing the keys in the table below, some of which also require the holding down of the key. The codes for uppercase and lowercase are swapped compared to ASCII.

Code	Key	PETSCII	ASCII
$5C	Pound	£	\ (backslash)
$5E	Up Arrow (next to RESTORE)	↑	^ (caret)
$5F	Left Arrow (next to 1)	←	_ (underscore)
$7B	MEGA + Colon	┼	{ (open brace)
$7C	MEGA + Dot	▒	| (pipe)
$7D	MEGA + Semicolon	│	} (close brace)
$7E	MEGA + Comma	π	~ (tilde)

Remarks: The additional ASCII characters provided by FONT A and B are only available while using the lowercase character set.

Examples: Using **FONT**

```
FONT A :REM ASCII - ENABLE {|}_~^
FONT B :REM LIKE A, WITH A SERIF FONT
FONT C :REM COMMODORE FONT (DEFAULT)
```

FOR

Format: **FOR** index = start **TO** end [**STEP** step] ... **NEXT** [index]

Usage: **FOR** statements start a BASIC loop with an index variable.

index may be incremented or decremented by a constant value on each iteration. The default is to increment the variable by 1. The index variable must be a real variable.

start is used to initialise the index.

end is checked at the end of an iteration, and determines whether another iteration will be performed, or if the loop will exit.

step defines the change applied to to the index variable at the end of an iteration. Positive step values increment it, while negative values decrement it. It defaults to 1.0 if not specified.

Remarks: For positive increments **end** must be greater than or equal to **start**, whereas for negative increments **end** must be less than or equal to **start**.

It is bad programming practice to change the value of the **index** variable inside the loop or to jump into or out of a loop body with **GOTO**.

Examples: Using **FOR**

```
10 FOR D=0 TO 360 STEP 30
20 R = D * π / 180
30 PRINT D;R;SIN(R);COS(R);TAN(R)
40 NEXT D

10 DIM M(20,20)
20 FOR I=0 TO 20
30 FOR J=I TO 20
40 M(I,J) = I + 100 * J
50 NEXT J,I
```

FOREGROUND

Format: **FOREGROUND** colour

Usage: Sets the foreground text colour for subsequent **PRINT** commands.

colour the palette entry number, in the range 0 – 31

See appendix E on page 281 for the list of colours in the default system palette.

Remarks: This is another name for **COLOR**.

Example: Using **FOREGROUND**

```
READY.
FOREGROUND 7

READY.
█
```

FORMAT

Format: **FORMAT** diskname [**,I** id] [**,D** drive] [**,U** unit]

Usage: Formats a disk. *This erases all data on the disk.*

I The disk ID.

diskname is either a quoted string, e.g. "DATA" or a string expression in brackets, e.g. (DN$). The maximum length of **diskname** is 16 characters.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **FORMAT** is another name for the **HEADER** command.

For new floppy disks which have not already been formatted in MEGA65 (1581) format, it is necessary to specify the disk ID with the **I** parameter. This switches the format command to low level format, which writes sector IDs and erases all contents. This takes some time, as every block on the floppy disk will be written.

If the **I** parameter is omitted, a quick format will be performed. This is only possible if the disk has already been formatted as a MEGA65 or 1581 floppy disk. A quick format writes the new disk name and clears the block allocation map, marking all blocks as free. The disk ID is not changed, and blocks are not overwritten, so contents may be recovered with **ERASE R**. You can read more about **ERASE** on page 147.

Examples: Using **FORMAT**

```
FORMAT "ADVENTURE",IDK : FORMAT DISK WITH NAME ADVENTURE AND ID DK
FORMAT "ZORK-I",U9     : FORMAT DISK IN UNIT 9 WITH NAME ZORK-I
FORMAT "DUNGEON",D1,U10: FORMAT DISK IN DRIVE 1 UNIT 10 WITH NAME DUNGEON
```

FRE

Format: **FRE**(bank)

Returns: The number of free bytes for banks 0 or 1, or the ROM version if the argument is negative.

FRE(0) returns the number of free bytes in bank 0, which is used for BASIC program source.

FRE(1) returns the number of free bytes in bank 1, which is the bank for BASIC variables, arrays and strings. **FRE(1)** also triggers "garbage collection", which is a process that collects strings in use at the top of the bank, thereby defragmenting string memory.

FRE(-1) returns the ROM version, a six-digit number of the form `92XXXX`.

Example: Using **FRE**:

```
10 PM = FRE(0)
20 VM = FRE(1)
30 RV = FRE(-1)
40 PRINT PM;" FREE FOR PROGRAM"
50 PRINT VM;" FREE FOR VARIABLES"
60 PRINT RV;" ROM VERSION"
```

FREAD

Format: **FREAD#** channel**,** pointer**,** size

Usage: Reads **size** bytes from **channel** to memory starting at the 32-bit address **pointer**.

channel number, which was given to a previous call to commands such as **DOPEN**, or **OPEN**

FREAD can be used to read data from disk directly into a variable. It is recommended to use the **POINTER** statement for the pointer argument, and to compute the size parameter by multiplying the number of elements with the item size.

Type	**Item Size**
Byte Array	1
Integer Array	2
Real Array	5

Keep in mind that the **POINTER** function with a string argument does *not* return the string address, but the string descriptor. It is not recommended to use **FREAD** for strings or string arrays unless you are fully aware on how to handle the string storage internals.

To read into an array, ensure that you always specify an array index so that **POINTER** returns the address of an element. The start address of array `XY()` is `POINTER(XY(0))`. `POINTER(XY)` returns the address of the scalar variable `XY`.

Example: Using **FREAD**:

```
100 N=23
110 DIM B&(N),C&(N)
120 DOPEN#2,"TEXT"
130 FREAD#2,POINTER(B&(0)),N
140 DCLOSE#2
150 FORI=0TON-1:PRINTCHR$(B&(I));:NEXT
160 FORI=0TON-1:C&(I)=B&(N-1-I):NEXT
170 DOPEN#2,"REVERS",W
180 FWRITE#2,POINTER(C&(0)),N
190 DCLOSE#2
```

FREEZER

Format: **FREEZER**

Usage: Invokes the Freezer menu.

Remarks: Entering the **FREEZER** command is an alternative to holding and releasing the RESTORE key.

Examples: Using **FREEZER**

```
FREEZER :REM CALL FREEZER MENU
```

FWRITE

Format: **FWRITE#** channel**,** pointer**,** size

Usage: Writes **size** bytes to **channel** from memory starting at the 32-bit address **pointer**.

channel number, which was given to a previous call to commands such as **APPEND**, **DOPEN**, or **OPEN**.

FWRITE can be used to write the value of a variable to a file. It is recommended to use the **POINTER** statement for the pointer argument and compute the size parameter by multiplying the number of elements with the item size.

Refer to the **FREAD** item size table on page 157 for the item sizes.

Keep in mind that the **POINTER** function with a string argument does *not* return the string address, but the string descriptor. It is not recommended to use **FWRITE** for strings or string arrays unless you are fully aware on how to handle the string storage internals.

To write an array, ensure that you always specify an array index so that **POINTER** returns the address of an element. The start address of array `XY()` is `POINTER(XY(0))`. `POINTER(XY)` returns the address of the scalar variable `XY`.

Example: Using **FWRITE**:

```
100 N=23
110 DIM B&(N),C&(N)
120 DOPEN#2,"TEXT"
130 FREAD#2,POINTER(B&(0)),N
140 DCLOSE#2
150 FORI=0TON-1:PRINTCHR$(B&(I));:NEXT
160 FORI=0TON-1:C&(I)=B&(N-1-I):NEXT
170 DOPEN#2,"REVERS",W
180 FWRITE#2,POINTER(C&(0)),N
190 DCLOSE#2
```

GCOPY

Format: **GCOPY** x, y, width, height

Usage: Bitmap graphics: copies the content of the specified rectangle with upper left position **x, y** and the **width** and **height** to a buffer.

The copied region can be inserted at any position with the command **PASTE**.

Remarks: The size of the rectangle is limited by the 1K size of the buffer. The memory requirement for a region is width * height * number of bit-planes / 8. It must not equal or exceed 1024 byte. For a 4-bitplane screen for example, a 45 x 45 region needs 1012.5 byte.

Example: Using **GCOPY** (see also **CUT**).

```
10 SCREEN 320,200,2
20 BOX 60,60,300,180,1  :REM DRAW A WHITE BOX
30 GCOPY 140,80,40,40   :REM COPY A 40 * 40 REGION
40 PASTE 10,10,40,40    :REM PASTE IT TO NEW POSITION
50 GETKEY A$            :REM WAIT FOR KEYPRESS
60 SCREEN CLOSE
```

GET

Format: **GET** variable

Usage: Gets the next character, or byte value of the next character, from the keyboard queue.

If the variable being set to the character is of type string and the queue is empty, an empty string is assigned to it, otherwise a one character string is created and assigned instead. If the variable is of type numeric, the byte value of the key is assigned to it, otherwise zero will be assigned if the queue is empty. **GET** does not wait for keyboard input, so it's useful to check for key presses at regular intervals or in loops.

Remarks: **GETKEY** is similar, but waits until a key has been pressed.

Example: Using **GET**:

```
10 DO: GET A$: LOOP UNTIL A$ <> ""
40 IF A$ = "W" THEN 1000 :REM GO NORTH
50 IF A$ = "A" THEN 2000 :REM GO WEST
60 IF A$ = "S" THEN 3000 :REM GO EAST
70 IF A$ = "Z" THEN 4000 :REM GO SOUTH
80 IF A$ = CHR$(13) THEN 5000 :REM RETURN
90 GOTO 10
```

GET#

Format: **GET#** channel**,** variable [**,** variable ...]

Usage: Reads a single byte from the channel argument and assigns single character strings to string variables, or an 8-bit binary value to numeric variables.

This is useful for reading characters (or bytes) from an input stream one byte at a time.

channel number, which was given to a previous call to commands such as **DOPEN**, or **OPEN**.

Remarks: All values from 0 to 255 are valid, so **GET#** can also be used to read binary data.

Example: Using **GET#** to read a disk directory:

```
1 REM GET#
10 OPEN 2,8,0,"$"           : REM OPEN CATALOG
15 IF DS THEN PRINT DS$: STOP: REM CANT READ
20 GET#2,D$,D$              : REM DISCARD LOAD ADDRESS
25 DO                       : REM LINE LOOP
30   GET#2,D$,D$            : REM DISCARD LINE LINK
35   IF ST THEN EXIT        : REM END-OF-FILE
40   GET#2,LO,HI            : REM FILE SIZE BYTES
45   S=LO + 256 * HI        : REM FILE SIZE
50   LINE INPUT#2, F$       : REM FILE NAME
55   PRINT S;F$             : REM PRINT FILE ENTRY
60 LOOP
65 CLOSE 2
```

GETKEY

Format: **GETKEY** variable

Usage: Gets the next character, or byte value of the next character, from the keyboard queue. If the queue is empty, the program will wait until a key has been pressed.

After a key has been pressed, the variable will be set and program execution will continue. When used with a string variable, a one character string is created and assigned. Otherwise if the variable is of type numeric, the byte value is assigned.

Example: Using **GETKEY**:

```
10 GETKEY A$ :REM WAIT AND GET CHARACTER
40 IF A$ = "W" THEN 1000 :REM GO NORTH
50 IF A$ = "A" THEN 2000 :REM GO WEST
60 IF A$ = "S" THEN 3000 :REM GO EAST
70 IF A$ = "Z" THEN 4000 :REM GO SOUTH
80 IF A$ = CHR$(13) THEN 5000 :REM RETURN
90 GOTO 10
```

GO64

Format: **GO64**

Usage: Switches the MEGA65 to C64-compatible mode.

If you're in direct mode, a security prompt `ARE YOU SURE?` is displayed, which must be responded with `Y` to continue.

You can switch back to MEGA65 mode with this command: `SYS58552`

Example: Using **GO64**:

```
GO64
ARE YOU SURE?
```

GOSUB

Format: **GOSUB** line

Usage: **GOSUB** (GOto SUBroutine) continues program execution at the given BASIC line number, saving the current BASIC program counter and line number on the run-time stack. This enables the resumption of execution after the **GOSUB** statement, once a **RETURN** statement in the called subroutine is executed. Calls to subroutines via **GOSUB** may be nested, but the subroutines must always end with **RETURN**, otherwise a stack overflow may occur.

Remarks: Unlike other programming languages, BASIC 65 does not support arguments or local variables for subroutines.
Programs can be optimised by grouping subroutines at the beginning of the program source. The **GOSUB** calls will then have low line numbers with fewer digits to decode. The subroutines will also be found faster, since the search for subroutines often starts at the beginning of the program.

Example: Using **GOSUB**:

```
 10 GOTO 100 :REM TO MAIN PROGRAM
 20 REM *** SUBROUTINE DISK STATUS CHECK ***
 30 DD=DS:IF DD THEN PRINT "DISK ERROR";DS$
 40 RETURN
 50 REM *** SUBROUTINE PROMPT Y/N ***
 60 DO:INPUT "CONTINUE (Y/N)";A$
 70 LOOP UNTIL A$="Y" OR A$="N"
 80 RETURN
 90 REM *** MAIN PROGRAM ***
100 DOPEN#2,"BIG DATA"
110 GOSUB 30: IF DD THEN DCLOSE#2:GOSUB 60:REM ASK
120 IF A$="N" THEN STOP
130 GOTO 100: REM RETRY
```

GOTO

Format: **GOTO** line
GO TO line

Usage: Continues program execution at the given BASIC line number.

Remarks: If the target **line** number is higher than the current line number, the search starts from the current line, proceeding to higher line numbers. If the target **line** number is lower, the search starts at the first **line** number of the program. It is possible to optimise the run-time speed of the program by grouping often used targets at the start (with lower line numbers).

GOTO (written as a single word) executes faster than **GO TO**.

Example: Using **GOTO**:

```
 10 GOTO 100 :REM TO MAIN PROGRAM
 20 REM *** SUBROUTINE DISK STATUS CHECK ***
 30 DD=DS:IF DD THEN PRINT "DISK ERROR";DS$
 40 RETURN
 50 REM *** SUBROUTINE PROMPT Y/N ***
 60 DO:INPUT "CONTINUE (Y/N)";A$
 70 LOOP UNTIL A$="Y" OR A$="N"
 80 RETURN
 90 *** MAIN PROGRAM ***
100 DOPEN#2,"BIG DATA"
110 GOSUB 30: IF DD THEN DCLOSE#2:GOSUB 60:REM ASK
120 IF A$="N" THEN STOP
130 GOTO 100: REM RETRY
```

GRAPHIC

Format: **GRAPHIC CLR**

Usage: Bitmap graphics: initialises the BASIC bitmap graphics system. It clears the graphics memory and screen, and sets all parameters of the graphics context to their default values.

Once the graphics system has been cleared, commands such as **LINE**, **PALETTE**, **PEN**, **SCNCLR**, and **SCREEN** can be used to set graphics system parameters.

Example: Using **GRAPHIC**:

```
100 REM GRAPHIC
110 GRAPHIC CLR        : REM INITIALISE
120 SCREEN DEF 1,1,1,2 : REM 640 X 400 X 2
130 SCREEN OPEN 1      : REM OPEN IT
140 SCREEN SET 1,1     : REM VIEW IT
150 PALETTE 1,0,0, 0,0 : REM BLACK
160 PALETTE 1,1,0,15,0 : REM GREEN
170 SCNCLR 0           : REM FILL SCREEN WITH BLACK
180 PEN 0,1            : REM SELECT PEN
190 LINE 50,50,590,350 : REM DRAW LINE
200 GETKEY A$          : REM WAIT FOR KEYPRESS
210 SCREEN CLOSE 1     : REM CLOSE SCREEN AND RESTORE PALETTE
```

HEADER

Format: **HEADER** diskname [**,I** id] [**,D** drive] [**,U** unit]

Usage: Formats a disk. *This erases all data on the disk.*

I The disk ID.

diskname is either a quoted string, e.g. `"DATA"` or a string expression in brackets, e.g. `(DN$)`. The maximum length of **diskname** is 16 characters.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **HEADER** is another name for the **FORMAT** command.

For new floppy disks which have not already been formatted in MEGA65 (1581) format, it is necessary to specify the disk ID with the **I** parameter. This switches the format command to low level format, which writes sector IDs and erases all contents. This takes some time, as every block on the floppy disk will be written.

If the **I** parameter is omitted, a quick format will be performed. This is only possible if the disk has already been formatted as a MEGA65 or 1581 floppy disk. A quick format writes the new disk name and clears the block allocation map, marking all blocks as free. The disk ID is not changed, and blocks are not overwritten, so contents may be recovered with **ERASE R**. You can read more about **ERASE** on page 147.

Examples: Using **HEADER**

```
HEADER "ADVENTURE",IDK : FORMAT DISK WITH NAME ADVENTURE AND ID DK
HEADER "ZORK-I",U9     : FORMAT DISK IN UNIT 9 WITH NAME ZORK-I
HEADER "DUNGEON",D1,U10: FORMAT DISK IN DRIVE 1 UNIT 10 WITH NAME DUNGEON
```

HELP

Format: **HELP**

Usage: Displays information about where an error occurred in a BASIC program.

When the BASIC program stops due to an error, **HELP** can be used to gain further information. The interpreted line is listed, with the erroneous statement highlighted or underlined.

Remarks: Displays BASIC errors. For errors related to disk I/O, the disk status variable **DS** or the disk status string **DS$** should be used instead.

Example: Using **HELP**

```
10 A=1.E20
20 B=A+A:C=EXP(A):PRINT A,B,C
RUN

?OVERFLOW ERROR IN 20
READY.
HELP

20 B=A+A:C=EXP(A):PRINT A,B,C
```

HEX$

Format: **HEX$**(numeric expression)

Returns: A four character hexadecimal representation of the argument.

The argument must be in the range of 0 – 65535, corresponding to the hex numbers $0000-$FFFF.

Remarks: If real numbers are used as arguments, the fractional part will be ignored. In other words, real numbers will not be rounded.

Example: Using **HEX$**:

```
PRINT HEX$(10),HEX$(100),HEX$(1000.9)
000A      0064      03E8
```

HIGHLIGHT

Format: **HIGHLIGHT** colour [, mode]

Usage: Sets the colours used for code highlighting.

Different colours can be set for system messages, **REM** statements and BASIC 65 keywords.

colour is one of the first 16 colours in the current palette. See appendix E on page 281 for the list of colours in the default system palette.

mode indicates what the colour will be used for.

- **0** system messages (the default mode)
- **1** **REM** statements
- **2** BASIC keywords

Remarks: The system messages colour is used when displaying error messages, and in the output of **CHANGE**, **FIND**, and **HELP**. The colours for **REM** statements and BASIC keywords are used by **LIST**.

Example: Using **HIGHLIGHT** to change the colour of BASIC keywords to red.

```
LIST

10 REM *** THIS IS HELLO WORLD ***
20 PRINT "HELLO WORLD"

READY.
HIGHLIGHT 8,2

READY.
LIST

10 REM *** THIS IS HELLO WORLD ***
20 PRINT "HELLO WORLD"

READY.
█
```

IF

Format: **IF** expression **THEN** true clause [**ELSE** false clause]

Usage: Starts a conditional execution statement.

expression a logical or numeric expression. A numeric expression is evaluated as **FALSE** if the value is zero and **TRUE** for any non-zero value.

true clause one or more statements starting directly after **THEN** on the same line. A line number after **THEN** performs a **GOTO** to that line instead.

false clause one or more statements starting directly after **ELSE** on the same line. A linenumber after **ELSE** performs a **GOTO** to that line instead.

Remarks: The standard **IF ... THEN ... ELSE** structure is restricted to a single line. But the **true clause** and **false clause** may be expanded to several lines using a compound statement surrounded with **BEGIN** and **BEND**.

Example: Using **IF**

```
1 REM IF
10 RED$=CHR$(28) : BLACK$=CHR$(144) : WHITE$=CHR$(5)
20 INPUT "ENTER A NUMBER";V
30 IF V<0 THEN PRINT RED$; : ELSE PRINT BLACK$;
40 PRINT V : REM PRINT NEGATIVE NUMBERS IN RED
50 PRINT WHITE$
60 INPUT "END PROGRAM: (Y/N)"; A$
70 IF A$="Y" THEN END
80 IF A$="N" THEN 20 : ELSE 60
```

IMPORT

Format: **IMPORT** filename [**,D** drive] [**,U** unit]

Usage: Loads BASIC code in text format from a file of type **SEQ** into memory reserved for BASIC programs.

filename the name of a file. Either a quoted string such as "DATA", or a string expression in brackets such as (FI$).

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: The program is loaded into BASIC memory and converted from text to the tokenised form of **PRG** files. This enables loading of BASIC programs that were saved as plain text files as program listing.

After loading, the program is re-linked and ready to be **RUN** or edited. It is possible to use **IMPORT** for merging a program text file from disk to a program already in memory. Each line read from the file is processed in the same way, as if typed from the user with the screen editor.

There is no **EXPORT** counterpart, because this function is already available. The sequence `DOPEN#1,"LISTING",W:CMD 1:LIST:DCLOSE#1` converts the program in memory to text and writes it to the file, that is named in the **DOPEN** statement.

Examples: Using **IMPORT**

```
IMPORT "APOCALYPSE"
IMPORT "MEGA TOOLS",U9
IMPORT (FI$),U(UN%)
```

INFO

Format: **INFO**

Usage: Displays information about the runtime environment.

Remarks: The **INFO** command displays information about the BASIC runtime environment, including:

- The video mode (PAL, NTSC)
- The version of the ROM
- The CPU speed
- The current **MEM** setting
- Memory used and memory available for program text and variables

Examples: Using **INFO**

```
INFO
```

INPUT

Format: **INPUT** [prompt <**,** | **;**>] variable [**,** variable ...]

Usage: Prompts the user for keyboard input, printing an optional prompt string and question mark to the screen.

prompt optional string expression to be printed as the prompt

If the separator between **prompt** and **variable list** is a comma, the cursor is placed directly after the prompt. If the separator is a semicolon, a question mark and a space is added to the prompt instead.

variable list list of one or more variables that receive the input

The input will be processed after the user presses RETURN.

Remarks: The user must take care to enter the correct type of input, so it matches the **variable list** types. Also, the number of input items must match the number of variables. A surplus of input items will be ignored, whereas too few input items trigger another request for input with the prompt ??. Typing non numeric characters for integer or real variables will produce a TYPE MISMATCH ERROR. Strings for string variables must be in double quotes (") if they contain spaces or commas. Many programs that need a safe input routine use **LINE INPUT** and a custom parser, in order to avoid program errors by wrong user input.

Example: Using **INPUT**:

```
 10 DIM N$(100),A%(100),S$(100):
 20 DO
 30 INPUT "NAME, AGE, GENDER";NA$,AG%,SE$
 40 IF NA$="" THEN 30
 50 IF NA$="END" THEN EXIT
 60 IF AG% < 18 OR AG% > 100 THEN PRINT "AGE?":GOTO 30
 70 IF SE$ <> "M" AND SE$ <> "F" THEN PRINT "GENDER?":GOTO 30
 80 REM CHECK OK: ENTER INTO ARRAY
 90 N$(N)=NA$:A%(N)=AG%:S$(N)=SE$:N=N+1
100 LOOP UNTIL N=100
110 PRINT "RECEIVED";N;" NAMES"
```

INPUT#

Format: **INPUT#** channel**,** variable [**,** variable ...]

Usage: Reads a record from an input device, e.g. a disk file, and assigns the data to the variables in the list.

channel number, which was given to a previous call to commands such as **DOPEN**, or **OPEN**.

variable list list of one or more variables, that receive the input.

The input record must be terminated by a RETURN character and must be not longer than the input buffer (160 characters).

Remarks: The type and number of data in a record must match the variable list. Reading non numeric characters for integer or real variables will produce a `FILE DATA ERROR`. Strings for string variables have to be put in quotes if they contain spaces or commas.
LINE INPUT# may be used to read a whole record into a single string variable.

Sequential files, that can be read by **INPUT#** can be generated by programs with **PRINT#** or with the editor of the MEGA65. For example:

```
EDIT ON

10 "CHUCK PEDDLE",1937,"ENGINEER OF THE 6502"
20 "JACK TRAMIEL",1928,"FOUNDER OF CBM"
30 "BILL MENSCH",1945,"HARDWARE"

DSAVE "CBM-PEOPLE"
EDIT OFF
```

Example: Using **INPUT#**:

```
 10 DIM N$(100),B%(100),S$(100):
 20 DOPEN#2,"CBM-PEOPLE":REM OPEN SEQ FILE
 25 IF DS THEN PRINT DS$:STOP:REM OPEN ERROR
 30 FOR I=0 TO 100
 40 INPUT#2,N$(I),B%(I),S$(I)
 50 IF ST AND 64 THEN 80:REM END OF FILE
 60 IF DS THEN PRINT DS$:GOTO 80:REM DISK ERROR
 70 NEXT I
 80 DCLOSE#2
110 PRINT "READ";I+1;" RECORDS"
120 FOR J=0 TO I:PRINT N$(J):NEXT J

RUN
READ 3  RECORDS
CHUCK PEDDLE
JACK TRAMIEL
BILL MENSCH

TYPE "CBM-PEOPLE"
"CHUCK PEDDLE",1937,"ENGINEER OF THE 6502"
"JACK TRAMIEL",1928,"FOUNDER OF CBM"
"BILL MENSCH",1945,"HARDWARE"
```

INSTR

Format: **INSTR(**haystack**,** needle [**,** start]**)**

Usage: Locates the position of the string expression **needle** in the string expression **haystack**, and returns the index of the first occurrence, or zero if there is no match.

The string expression **haystack** is searched for the occurrence of the string expression **needle**.

An enhanced version of string search using pattern matching is used if the first character of the search string is a pound sign '£'. The pound sign is not part of the search but enables the use of the **'.'** (dot) as a wildcard character, which matches any character. The second special pattern character is the **'*'** (asterisk) character. The asterisk in the search string indicates that the preceding character may never appear, appear once, or repeatedly in order to be considered as a match.

The optional argument **start** is an integer expression, which defines the starting position for the search in **haystack**. If not present, it defaults to one.

Remarks: If either string is empty or there is no match the function returns zero.

Examples: Using **INSTR**:

```
I = INSTR("ABCDEF","CD")      : REM I = 3
I = INSTR("ABCDEF","XY")      : REM I = 0
I = INSTR("RAIIIN","£A*IN")   : REM I = 5
I = INSTR("ABCDEF","£C.E")    : REM I = 3
I = INSTR(A$+B$,C$)
```

INT

Format: **INT**(numeric expression)

Returns: The integer part of a number.

This function is **NOT** limited to the typical 16-bit integer range (-32768 to 32767), as it uses real arithmetic. The allowed range is therefore determined by the size of the real mantissa which is 32-bits wide (-2147483648 to 2147483647).

Remarks: It is not necessary to use the **INT** function for assigning real values to integer variables, as this conversion will be done implicitly, but only for the 16-bit range.

Examples: Using **INT**:

```
X  = INT(1.9)       :REM X = 1
X  = INT(-3.1)      :REM X = -3
X  = INT(100000.5)  :REM X = 100000
N% = INT(100000.5)  :REM ?ILLEGAL QUANTITY ERROR
```

JOY

Format: **JOY**(port)

Returns: The state of the joystick for the selected controller port (1 or 2).

Bit 7 contains the state of the fire button. The stick can be moved in eight directions, which are numbered clockwise starting at the upper position.

	Left	Centre	Right
Up	8	1	2
Centre	7	0	3
Down	6	5	4

Example: Using **JOY**:

```
 10 N = JOY(1)
 20 IF N AND 128 THEN PRINT "FIRE! ";
 30 REM               N  NE  E  SE  S   SW  W   NW
 40 ON N AND 15 GOSUB 100,200,300,400,500,600,700,800
 50 GOTO 10
100 PRINT "GO NORTH"    :RETURN
200 PRINT "GO NORTHEAST":RETURN
300 PRINT "GO EAST"     :RETURN
400 PRINT "GO SOUTHEAST":RETURN
500 PRINT "GO SOUTH"    :RETURN
600 PRINT "GO SOUTHWEST":RETURN
700 PRINT "GO WEST"     :RETURN
800 PRINT "GO NORTHWEST":RETURN
```

KEY

Format:

KEY
KEY <**ON** | **OFF**>
KEY <**LOAD** | **SAVE**> filename
KEY number**,** string

Usage: Manages the function key macros in the BASIC editor.

Each function key can be assigned a string that is typed when pressed. The function keys have default assignments on boot, and can be changed by the **KEY** command.

KEY : list current assignments.

KEY ON : switch on function key strings. The keys will send assigned strings if pressed.

KEY OFF : switch off function key strings. The keys will send their character code if pressed.

KEY LOAD filename : loads key definitions from file.

KEY SAVE filename : saves key definitions to file.

KEY number**,** string : assigns the string to the key with the given number.

number can be any value within this range:

- **1 - 14**: corresponds to keys ranging from **F1** to **F14**
- **15**: corresponds to **HELP**

- **16**: corresponds to SHIFT RUN STOP

Default assignments:

```
KEY
KEY 1,CHR$(27)+"X"
KEY 2,CHR$(27)+"@"
KEY 3,"DIR"+CHR$(13)
KEY 4,"DIR "+CHR$(34)+"*=PRG"+CHR$(34)+CHR$(13)
KEY 5,"U"
KEY 6,"KEY6"+CHR$(141)
KEY 7,"L"
KEY 8,"MONITOR"+CHR$(13)
KEY 9,"P"
KEY 10,"KEY10"+CHR$(141)
KEY 11,"V"
KEY 12,"KEY12"+CHR$(141)
KEY 13,CHR$(27)+"O"
KEY 14,"U"+CHR$(27)+"O"
KEY 15,"HELP"+CHR$(13)
KEY 16,"RUN "+CHR$(34)+"*"+CHR$(34)+CHR$(13)
```

Remarks: The sum of the lengths of all assigned strings must not exceed 240 characters. Special characters such as RETURN or QUOTE are entered using their codes with the **CHR$** function. Refer to **CHR$** on page 114 for more information.

Examples: Using **KEY**:

```
KEY ON                 :REM ENABLE  FUNCTION KEYS
KEY OFF                :REM DISABLE FUNCTION KEYS
KEY                    :REM LIST ASSIGNMENTS
KEY 2,"PRINT π"+CHR$(14) :REM ASSIGN PRINT PI TO F2
KEY SAVE "MY KEY SET"  :REM SAVE CURRENT DEFINITIONS TO FILE
KEY LOAD "ELEVEN-SET"  :REM LOAD DEFINITIONS FROM FILE
```

LEFT$

Format: **LEFT$**(string, n)

Returns: A string containing the first **n** characters from the argument **string**.

If the length of **string** is equal to or less than **n**, the resulting string will be identical to the argument string.

string a string expression

n a numeric expression (0 - 255)

Remarks: Empty strings and zero length strings are legal values.

Example: Using **LEFT$**:

```
PRINT LEFT$("MEGA-65",4)
MEGA
```

LEN

Format: **LEN**(string)

Returns: The length of a string.

string a string expression

Remarks: Commodore BASIC strings can contain any character, including the null character. Internally, the length of a string is stored in a string descriptor.

Example: Using **LEN**:

```
PRINT LEN("MEGA-65"+CHR$(13))
 8
```

LET

Format: [**LET**] variable = expression

Usage: Assigns values (or results of expressions) to variables.

Remarks: The **LET** statement is obsolete and not required. Assignment to variables can be done without using **LET**, but it has been left in BASIC 65 for backwards compatibility.

Examples: Using **LET**:

```
LET A=5  :REM LONGER  AND SLOWER
A=5      :REM SHORTER AND FASTER
```

LINE

Format: **LINE** xbeg, ybeg [, xnext1, ynext1 ...]

Usage: Bitmap graphics: draws a line or series of lines.

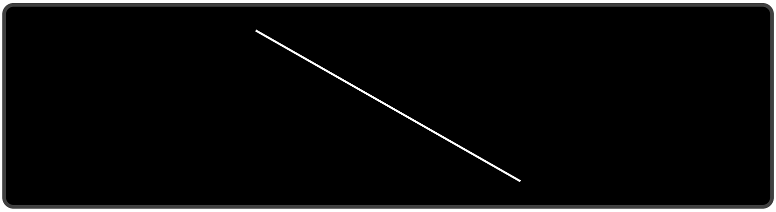
If only one coordinate pair is given, **LINE** draws a dot.

If more than one pair is defined, a line is drawn on the current graphics screen from the coordinate (xbeg/ybeg) to the next coordinate pair(s).

All currently defined modes and values of the graphics context are used.

Example: Using **LINE**:

```
1 REM SCREEN EXAMPLE 1
10 SCREEN 320,200,2      :REM SCREEN #0 320 X 200 X 2
20 PEN 1                 :REM DRAWING PEN COLOUR 1 (WHITE)
30 LINE 25,25,295,175    :REM DRAW LINE
40 GETKEY A$             :REM WAIT FOR KEYPRESS
50 SCREEN CLOSE          :REM CLOSE SCREEN AND RESTORE PALETTE
```



LINE INPUT

Format: **LINE INPUT** [prompt <**,** | **;**>] string variable [**,** string variable ...]

Usage: Prompts the user for keyboard input, printing an optional prompt string and question mark to the screen.

prompt optional string expression to be printed as the prompt

If the separator between **prompt** and the first **string variable** is a comma, the cursor is placed directly after the prompt. If the separator is a semicolon, a question mark and a space is added to the prompt instead.

string variable one or more string variables that accept one line of input each

Remarks: This differs from **INPUT** in how the input is parsed. **LINE INPUT** accepts every character entered on a line as a single string value. Only the RETURN key does not produce a character.

If the variable list has more than one variable, **LINE INPUT** will use the entire first line for the first variable, and present the ?? prompt for each subsequent variable.

LINE INPUT only works with string variables. If a non-string variable is used, **LINE INPUT** throws produces a TYPE MISMATCH ERROR after data has been entered.

Example: Using **LINE INPUT**:

```
10 LINE INPUT "ENTER A PHRASE: ",PH$
20 PRINT "THE PHRASE YOU ENTERED:";CHR$(13);"  ";PH$
RUN
ENTER A PHRASE: YOU SAY "POTATO," I SAY "POTATO."
THE PHRASE YOU ENTERED:
  YOU SAY "POTATO," I SAY "POTATO."
```

LINE INPUT#

Format: **LINE INPUT#** channel**,** variable [**,** variable ...]

Usage: Reads one record per variable from an input device, (such as a disk drive) and assigns the read data to the variable.

The records must be terminated by a **RETURN** character, which will not be copied to the string variable. Therefore, an empty line consisting of only the **RETURN** character will result in an empty string being assigned.

channel number, which was given to a previous call to commands such as **DOPEN**, or **OPEN**.

variable list list of one or more variables, that receive the input.

Remarks: Only string variables or string array elements can be used in the variable list. Unlike other INPUT commands, **LINE INPUT#** does not interpret or remove quote characters in the input. They are accepted as data, as all other characters.

Records must not be longer than the input buffer, which is 160 characters.

Example: Using **LINE INPUT#**:

```
 10 DIM N$(100)
 20 DOPEN#2,"DATA"
 30 FOR I=0 TO 100
 40 LINE INPUT#2,N$(I)
 50 IF ST=64 THEN 80:REM END OF FILE
 60 IF DS THEN PRINT DS$:GOTO 80:REM DISK ERROR
 70 NEXT I
 80 DCLOSE#2
110 PRINT "READ";I;" RECORDS"
```

LIST

Format: **LIST** [**P**] [line range]

Usage: Lists a range of lines from the BASIC program in memory.

Given a single line number, **LIST** lists that line.

Given a range of line numbers, **LIST** lists all lines in that range. A range can be two numbers separated by a hyphen (-), or it can omit the beginning or end of the range to imply the beginning or end of the program. (See examples below.)

Format: **LIST** [**P**] filename [**,U** unit]

Usage: Lists a range of lines from a BASIC program directly from a file.

Remarks: The optional parameter **P** enables page mode. After listing a screen-ful of lines, the listing will stop and display the prompt `[MORE]` at the bottom of the screen. Pressing **Q** quits page mode, while any other key continues to the next page.

LIST output can be redirected to other devices via **CMD**.

Another way to display a program listing from memory on the screen is to use the keys **F9** and **F11**, or **Ctrl** **P** and **Ctrl** **V**, to scroll a BASIC listing on screen up or down.

Examples: Using **LIST**

```
LIST 100      :REM LIST LINE 100
LIST 240-350  :REM LIST ALL LINES FROM 240 TO 350
LIST 500-     :REM LIST FROM 500 TO END
LIST -70      :REM LIST FROM START TO 70
LIST "DEMO"   :REM LIST FILE "DEMO"
LIST P        :REM LIST PROGRAM IN PAGE MODE
LIST P "MURX" :REM LIST FILE "MURX" IN PAGE MODE
```

LOAD

Format:

LOAD filename [, unit [, flag]]
LOAD "$[pattern=type]" [, **unit**]
LOAD "$$[pattern=type]" [, **unit**]
/ filename [, unit [, flag]]

Usage:

The first form loads a file of type **PRG** into memory reserved for BASIC programs.

The second form loads a directory into memory, which can then be viewed with **LIST**. It is structured like a BASIC program, but file sizes are displayed instead of line numbers.

The third form is similar to the second one, but the files are numbered. This listing can be scrolled like a BASIC program with the keys **F9** or **F11**, edited, listed, saved or printed.

A filter can be applied by specifying a pattern or a pattern and a type. The asterisk matches the rest of the name, while the ? matches any single character. The type specifier can be a character of (P,S,U,R), that is Program, Sequential, User, or Relative file.

A common use of the shortcut symbol **/** is to quickly load **PRG** files. To do this:

1. Print a disk directory using either **DIR**, or **CATALOG**.
2. Move the cursor to the desired line.
3. type **/** in the first column of the line, and press **RETURN**.

After pressing **RETURN**, the listed file on the line with the leading **/** will be loaded. Characters before and after the file name double quotes (") will be ignored. This applies to **PRG** files only.

filename is either a quoted string, e.g. `"PROG"`, or a string expression.

The unit number is optional. If not present, the default disk device is assumed.

If **flag** has a non-zero value, the file is loaded to the address which is read from the first two bytes of the file. Otherwise, it is loaded to the start of BASIC memory and the load address in the file is ignored.

Remarks:

LOAD loads files of type **PRG** into RAM bank 0, which is also used for BASIC program source.

LOAD "*" can be used to load the first **PRG** from the given **unit**.

LOAD "$" can be be used to load the list of files from the given **unit**. When using **LOAD "$"**, **LIST** can be used to print the listing to screen.

LOAD is implemented in BASIC 65 to keep it backwards compatible with BASIC V2.

The shortcut symbol **/** can only be used in direct mode.

By default the C64 uses **unit** 1, which is assigned to datasette tape recorders connected to the cassette port. However the MEGA65 uses **unit** 8 by default, which is assigned to the internal disk drive. This means you don't need to add `,8` to **LOAD** commands that use it.

Examples: Using **LOAD**

```
LOAD "APOCALYPSE"   :REM LOAD A FILE CALLED APOCALYPSE TO BASIC MEMORY
LOAD "MEGA TOOLS",9 :REM LOAD A FILE CALLED "MEGA TOOLS" FROM UNIT 9 TO BASIC MEMORY
LOAD "*",8,1        :LOAD THE FIRST FILE ON UNIT 8 TO RAM AS SPECIFIED IN THE FILE

LOAD "$"            :REM LOAD WHOLE DIRECTORY - WITH FILE SIZES
LOAD "$$"           :REM LOAD WHOLE DIRECTORY - SCROLLABLE
LOAD "$$X*=P"       :REM DIRECTORY, WITH PRG FILES STARTING with 'X'
```

LOADIFF

Format: **LOADIFF** filename [**,D** drive] [**,U** unit]

Usage: Bitmap graphics: loads an IFF file into graphics memory.

The IFF (Interchange File Format) is supported by many different applications and operating systems. **LOADIFF** assumes that files contain bitplane graphics which match the currently active graphics screen for resolution and colour depth.

Supported resolutions are:

Width	Height	Bitplanes	Colours	Memory
320	200	max. 8	max. 256	max. 64 K
640	200	max. 8	max. 256	max. 128 K
320	400	max. 8	max. 256	max. 128 K
640	400	max. 4	max. 16	max. 128 K

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: Tools are available to convert popular image formats to IFF. These tools are available on several operating systems, such as AMIGA OS, macOS, Linux, and Windows. For example, **ImageMagick** is a free graphics package that includes a tool called **convert**, which can be used to create IFF files in conjunction with the **ppmtoilbm** tool from the **Netbpm** package.

To use **convert** and **ppmtoilbm** for converting a JPG file to an IFF file on Linux:

```
convert <myImage.jpg> <myImage.ppm>
ppmtoilbm -aga <myImage.ppm> > <myImage.iff>
```

Example: Using **LOADIFF**

```
100 BANK128:SCNCLR
110 REM DISPLAY PICTURES IN 320 X 200 X 7 RESOLUTION
120 GRAPHIC CLR:SCREEN DEF 0,0,0,7:SCREEN OPEN 0:SCREEN SET 0,0
130 FORI=1TO7: READF$
140 LOADIFF(F$+".IFF"):SLEEP 4:NEXT
150 DATA ALIEN,BEAKER,JOKER,PICARD,PULP,TROOPER,RIPLEY
160 SCREEN CLOSE 0
170 PALETTE RESTORE
```

LOCK

Format: **LOCK** filename/pattern [**,D** drive] [**,U** unit]

Usage: Locks a file on disk, preventing it from being updated or deleted.

The specified file or a set of files, that matches the pattern, is locked and cannot be deleted with the commands **DELETE**, **ERASE** or **SCRATCH**.

The command **UNLOCK** removes the lock.

filename the name of a file. Either a quoted string such as "DATA", or a string expression in brackets such as (FI$).

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: In direct mode the number of locked files is printed. The second to last number from the message contains the number of locked files,

Examples: Using **LOCK**

```
LOCK "DRM",U9 :REM LOCK FILE DRM ON UNIT 9
03,FILES LOCKED,01,00
LOCK "BS*"    :REM LOCK ALL FILES BEGINNING WITH "BS"
03,FILES LOCKED,04,00
```

LOG

Format: **LOG**(numeric expression)

Returns: The natural logarithm of a number.

The natural logarithm uses Euler's number (**2.71828183**) as base, not base 10 which is typically used in log functions on a pocket calculator.

Remarks: The log function with base 10 can be computed by dividing the result by log(10). **LOG10()** provides this feature as a function.

Example: Using **LOG**

```
PRINT LOG(1)
 0

PRINT LOG(0)
 ?ILLEGAL QUANTITY ERROR

PRINT LOG(4)
 1.38629436

PRINT LOG(100) / LOG(10)
 2
```

LOG10

Format: **LOG10**(numeric expression)

Returns: The decimal logarithm of the argument.

The decimal logarithm uses 10 as base.

Example: Using **LOG10**

```
PRINT LOG10(1)
 0

PRINT LOG10(0)
 ?ILLEGAL QUANTITY ERROR

PRINT LOG10(5)
 0.69897

PRINT LOG10(100);LOG10(10);LOG10(1);LOG10(0.1);LOG10(0.01)
 2  1  0 -1 -2
```

LOOP

Format: **DO** ... **LOOP**
DO [<**UNTIL** | **WHILE**> logical expression]
. . . statements [**EXIT**]
LOOP [<**UNTIL** | **WHILE**> logical expression]

Usage: **DO** and **LOOP** define the start of a BASIC loop. Using **DO** and **LOOP** alone without any modifiers creates an infinite loop, which can only be exited by the **EXIT** statement. The loop can be controlled by adding **UNTIL** or **WHILE** after the **DO** or **LOOP**.

Remarks: **DO** loops may be nested. An **EXIT** statement only exits the current loop.

Examples: Using **DO** and **LOOP**

```
10 PW$="":DO
20 GET A$:PW$=PW$+A$
30 LOOP UNTIL LEN(PW$)>7 OR A$=CHR$(13)

10 DO : REM WAIT FOR USER DECISION
20 GET A$
30 LOOP UNTIL A$="Y" OR A$="N" OR A$="y" OR A$="n"

10 DO WHILE ABS(EPS) > 0.001
20 GOSUB 2000 : REM ITERATION SUBROUTINE
30 LOOP

10 I%=0 : REM INTEGER LOOP 1-100
20 DO I%=I%+1
30 LOOP WHILE I% < 101
```

LPEN

Format: **LPEN**(coordinate)

Returns: The state of a light pen peripheral.

This function requires the use of a CRT monitor (or TV), and a light pen. It will not work with an LCD or LED screen. The light pen must be connected to port 1.

LPEN(0) returns the X position of the light pen, the range is 60 - 320.

LPEN(1) returns the Y position of the light pen, the range is 50 - 250.

Remarks: The X resolution is two pixels, therefore **LPEN(0)** only returns even numbers. A bright background colour is needed to trigger the light pen. The **COLLISION** statement may be used to enable an interrupt handler.

Example: Using **LPEN**

```
PRINT LPEN(0),LPEN(1)   :REM PRINT LIGHT PEN COORDINATES
```

MEM

Format: **MEM mask4,mask5**

Usage: Reserves memory in banks 4 or 5 such that the bitmap graphics system will not use it.

mask4 and **mask5** are byte values, that are interpreted as mask of 8 bits. Each bit set to 1 reserves an 8K segment of memory in bank 4 for the first argument and in bank 5 for the second argument.

bit	memory segment
0	$0000 - $1FFF
1	$2000 - $3FFF
2	$4000 - $5FFF
3	$6000 - $7FFF
4	$8000 - $9FFF
5	$A000 - $BFFF
6	$C000 - $DFFF
7	$E000 - $FFFF

Remarks: After reserving memory with **MEM** the graphics library will not use the reserved areas, so it can be used for other purposes. Access to bank 4 and 5 is possible with the commands **PEEK, WPEEK, POKE, WPOKE** and **EDMA**.

If a graphics screen cannot be opened, because the remaining memory is not sufficient, the program stops with a ?OUT OF MEMORY ERROR.

Some direct mode commands like **RENUMBER** use memory in banks 4 and 5 and do not honour **MEM** reservations. Such reservations are only guaranteed during program execution.

When 80 × 50 text mode is enabled, segment 0 is reserved automatically and used for screen data. It always uses segment 0, even if it was previously reserved with **MEM** or a graphic screen. If your program uses 80 × 50 text mode and also reserves a region with **MEM**, be sure to set region 0 as reserved, and do not use it for other purposes.

Example: Using **MEM**

```
10 MEM 1,3       :REM RESERVE $40000 - $41FFF AND $50000 - $53FFF
20 SCREEN 320,200 :REM SCREEN WILL NOT USE RESERVED SEGMENTS
40 EDMA 3,$2000,0,$4000:REM FILL SEGMENT WITH ZEROES
```

MERGE

Format: **MERGE** filename [**,D** drive] [**,U** unit]

Usage: Loads a BASIC program file from disk and appends it to the program in memory.

filename the name of a file. Either a quoted string such as "DATA", or a string expression in brackets such as (FI$).

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: The load address that is stored in the first two bytes of the file is ignored. The loaded program does not replace a program in memory (which is what **DLOAD** does), but is appended to a program in memory. After loading, the program is re-linked and ready to run or edit.

It is the user's responsibility to ensure that there are no line number conflicts among the program in memory and the merged program. The first line number of the merged program must be greater than the last line number of the program in memory.

Example: Using **MERGE**

```
DLOAD "MAIN PROGRAM"
MERGE "LIBRARY"
```

MID$

Format: **MID$(**string**,** index**,** n**)**
MID$(string variable**,** index**,** n**)** = string expression

Usage: As a function, the substring of a string. As a statement, replaces a substring of a string variable with another string.

string a string expression.

index start index (1 – 255).

n length of sub-string (0 – 255).

Remarks: Empty strings and zero lengths are legal values.

Example: Using **MID$**:

```
10 A$ = "MEGA-65"
20 PRINT MID$(A$,3,4)
30 MID$(A$,5,1) = "+"
40 PRINT A$
RUN
GA-6
MEGA+65
```

MKDIR

Format: **MKDIR** dirname **,L** size [**,U** unit]

Usage: Makes (creates) a subdirectory on a floppy or D81 disk image.

dirname the name of a directory. Either a quoted string such as `"SOMEDIR"`, or a string expression in brackets such as `(DR$)`.

MKDIR can only be used on units managed by CBDOS. These are the internal floppy disk drive and SD-Card images of **D81** type. The command cannot be used on external drives connected to the serial IEC bus.

The **size** parameter specifies the number of tracks, to be reserved for the subdirectory, with one track = 40 sectors at 256 byte. The first track of the reserved range is used as directory track for the subdirectory.

The minimum size is 3 tracks, the maximm 38 tracks. There must be a contiguous region of empty tracks on the floppy (D81 image), that is large enough for the creation of the subdirectory. The error message DISK FULL is reported if there isn't such a region.

Several subdirectories may be created as long as there are enough empty tracks.

After successful creation of the subdirectory an automatic **CHDIR** into this subdirectory is performed.

CHDIR "/" changes back to the root directory.

Examples: Using **MKDIR**

```
MKDIR "SUBDIR",L5   :REM MAKE SUBDIRECTORY WITH 5 TRACKS
DIR
0 "SUBDIR          "    1D
160 BLOCKS FREE.
```

MOD

Format: **MOD**(dividend, divisor)

Returns: The remainder of a division operation.

Remarks: In other programming languages such as C, this function is implemented as an operator (%). In BASIC 65 it is implemented as a function.

Example: Using **MOD**:

```
FOR I = 0 TO 8: PRINT MOD(I,4);: NEXT I
 0  1  2  3  0  1  2  3  0
```

MONITOR

Format: **MONITOR**

Usage: Invokes the machine language monitor.

Remarks: Using the **MONITOR** requires knowledge of the CSG4510 / 6502 / 6510 CPU, the assembly language they use, and their architectures.

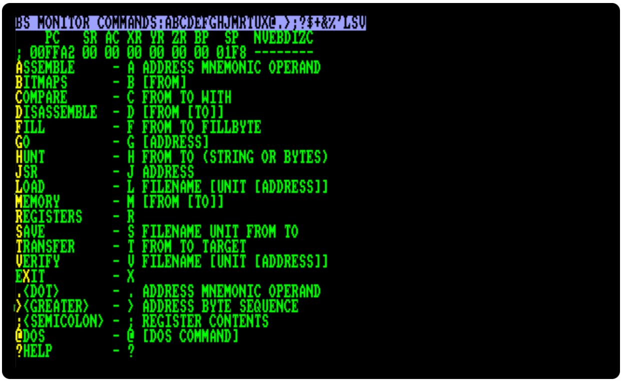
More information on the **MONITOR** is available in the **MEGA65 Book**.

To exit the monitor press **X**.

Help text can be displayed with either **?** or **H**.

Example: Using **MONITOR**

```
MONITOR
```



MOUNT

Format: **MOUNT** filename [**,U** unit]

Usage: Mounts a floppy image file of type **D81** from SD-Card to unit 8 (default) or unit 9.

If no argument is given, **MOUNT** assigns the real floppy drive of the MEGA65 to unit 8.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **MOUNT** can be used either in direct mode or in a program. It searches the file on the SD-card and mounts it, as requested, on unit 8 or 9. After mounting the floppy image can be used as usual with all DOS commands.

Examples: Using **MOUNT**

```
MOUNT "APOCALYPSE.D81"  ;REM MOUNT IMAGE TO UNIT 8
MOUNT "BASIC.D81",U9    :REM MOUNT IMAGE TO UNIT 9
MOUNT (FI$),U(UN%)      :REM MOUNT WITH VARIABLE ARGUMENTS
MOUNT                   :REM SELECT REAL FLOPPY DRIVE
```

MOUSE

Format: **MOUSE ON** [{**,** port**,** sprite**,** hotspot**,** pos}]
MOUSE OFF

Usage: Enables the mouse driver and connects the mouse at the specified port with the mouse pointer sprite.

port mouse port 1 or 2 (default 2).

sprite sprite number for mouse pointer (default 0).

hostpot location of the "hot spot" that determines the position and click target (x,y) (default 0,0).

pos initial mouse position (x,y). If not specified, uses the last known position of the sprite.

MOUSE OFF disables the mouse driver and hides the associated sprite.

Remarks: The "hot spot" of the mouse specifies where in the mouse sprite image is considered the click target, such as the top of an arrow or the center of a target reticle. The hot spot is always kept within the screen border. The default **hotspot** is 0,0, representing the top left corner of the sprite.

When the system boots, sprite 0 is initialised to a picture of a mouse pointer, with the hot spot at 0,0.

Use **RMOUSE** to test the location and button status of the mouse. This returns the coordinates of the top-left corner of the sprite, not the coordinates of the hot spot. To get the coordinates of the hot spot, add the hot spot location to the sprite coordinates.

pos can be an absolute coordinate, or a relative coordinate to the current mouse position, similar to **MOVSPR**.

Examples: Using **MOUSE**:

```
REM LOAD DATA INTO SPRITE #0 BEFORE USING IT
MOUSE ON, 1       :REM ENABLE  MOUSE WITH SPRITE #0
MOUSE OFF         :REM DISABLE MOUSE

MOUSE ON,1,0,2,4  :REM SET THE HOT SPOT TO (2,4)
RMOUSE X,Y,B      :REM FETCH MOUSE SPRITE COORDINATES
X=X+2 : Y=Y+4     :REM CALCULATE THE COORDINATES OF THE HOT SPOT

REM SET THE INITIAL POSITION TO X=300 Y=75
MOUSE ON,1,0,0,0,300,75
```

MOVSPR

Format: **MOVSPR** number**,** position

Usage: Moves a sprite to a location on screen.

Each **position** argument consists of two 16-bit values, which specify either an absolute coordinate, a relative coordinate, an angle, or a speed. The value type is determined by a prefix:

- **+value** relative coordinate: positive offset.
- **-value** relative coordinate: negative offset.
- **#value** speed.

If no prefix is given, the absolute coordinate or angle is used.

Therefore, the position argument can be used to either:

- set the sprite to an absolute position on screen.
- specify a displacement relative from the current position.
- trigger a relative movement from a specified position.
- describe movement with an angle and speed starting from the current position.

MOVSPR number, position is used to set the sprite immediately to the position or, in the case of an angle#speed argument, describe its further movement.

Format: **MOVSPR** number**,** start-position **TO** end-position**,** speed

Usage: Places the sprite at the start position, defines the destination position, and the speed of movement.

The sprite is placed at the start position, and will move in a straight line to the destination at the given speed. Coordinates must be absolute or relative. The movement is controlled by the BASIC interrupt handler and happens concurrently with the program execution.

number sprite number (0 – 7).

position x,y | xrel,y | x,yrel | xrel,yrel | angle#speed.

x absolute screen coordinate pixel.

y absolute screen coordinate pixel.

xrel relative screen coordinate pixel.

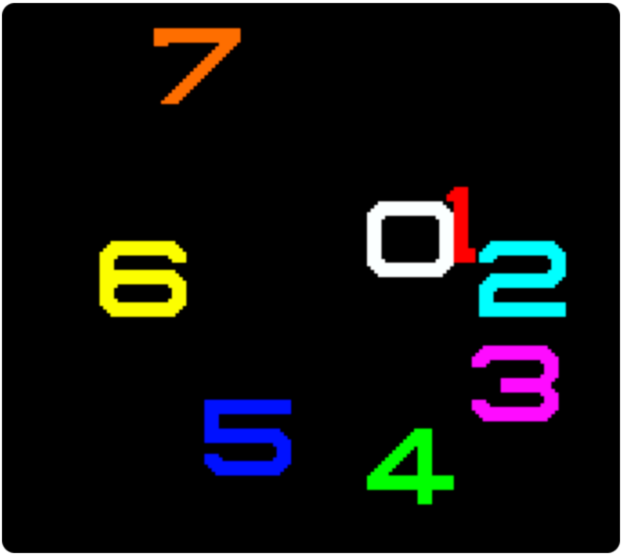
yrel relative screen coordinate pixel.

angle compass direction for sprite movement [degrees]. 0: up, 90: right, 180: down, 270: left, 45 upper right, etc.

speed speed of movement, configured as a floating point number in the range of 0.0 – 127.0, in pixels per frame. PAL has 50 frames per second whereas NTSC has 60 frames per second. A speed value of 1.0 will move the sprite 50 pixels per second in PAL mode.

Example: Using **MOVSPR**:

```
100 CLR:SCNCLR:SPRITECLR
110 BLOAD "DEMOSPRITES1",B0,P1536
130 FORI=0TO7: C=I+1:SP=0.07*(I+1)
140 MOVSPRI, 160,120
145 MOVSPRI,45*I#SP
150 SPRITEI,1,C,,0,0
160 NEXT
170 SLEEP 3
180 FORI=0TO7:MOVSPR I,0#0:NEXT
```



NEW

Format: **NEW**
NEW RESTORE

Usage: Erases the BASIC program in memory, and resets all BASIC parameters to their default values.

Since **NEW** resets parameters and pointers, (but does not overwrite the address range of a BASIC program that was in memory), it is possible to recover the program. If there were no **LOAD** operations, or editing performed after **NEW**, the program can be restored with the **NEW RESTORE**.

Examples: Using **NEW**:

```
NEW         :REM RESET BASIC
NEW RESTORE :REM TRY TO RECOVER NEW'ED PROGRAM
```

NEXT

Format: **FOR** index = start **TO** end [**STEP** step] ... **NEXT** [index]

Usage: Marks the end of the BASIC loop associated with the given index variable. When a BASIC loop is declared with **FOR**, it must end with **NEXT**.

The **index** variable may be incremented or decremented by a constant value **step** on each iteration. The default is to increment the variable by 1. The index variable must be a real variable.

start value to initialise the index with.

end is checked at the end of an iteration, and determines whether another iteration will be performed, or if the loop will exit.

step defines the change applied to to the index variable at the end of every iteration. Positive step values increment it, while negative values decrement it. It defaults to 1.0 if not specified.

Remarks: The **index** variable after **NEXT** is optional. If it is omitted, the variable for the current loop is assumed. Several consecutive **NEXT** statements may be combined by specifying the indexes in a comma separated list. The statements `NEXT I:NEXT J:NEXT K` and `NEXT I,J,K` are equivalent.

Example: Using **NEXT**

```
10 FOR D=0 TO 360 STEP 30
20 R = D * π / 180
30 PRINT D;R;SIN(R);COS(R);TAN(R)
40 NEXT D

10 DIM M(20,20)
20 FOR I=0 TO 20
30 FOR J=I TO 20
40 M(I,J) = I + 100 * J
50 NEXT J,I
```

NOT

Format: **NOT** operand

Usage: Performs a bit-wise logical NOT operation on a 16-bit value.

Integer operands are used as they are, whereas real operands are converted to a signed 16-bit integer (losing precision). Logical operands are converted to a 16-bit integer, using $FFFF (decimal -1) for TRUE, and $0000 (decimal 0) for FALSE.

Expression	Result
`NOT 0`	`1`
`NOT 1`	`0`

Remarks: The result is of type integer.

Examples: Using **NOT**

```
PRINT NOT 3
-4
PRINT NOT 64
-65
```

In most cases, **NOT** is used in **IF** statements.

```
OK = C < 256 AND C >= 0
IF (NOT OK) THEN PRINT "NOT A BYTE VALUE"
```

OFF

Format: keyword **OFF**

Usage: **OFF** is a secondary keyword used in combination with primary keywords, such as **KEY** and **MOUSE**.

Remarks: **OFF** cannot be used on its own.

Examples: Using **OFF**

```
KEY OFF   :REM DISABLE FUNCTION KEY STRINGS
MOUSE OFF :REM DISABLE MOUSE DRIVER
```

ON

Format: **ON** expression **GOSUB** line number [**,** line number ...]
ON expression **GOTO** line number [**,** line number ...]
keyword **ON**

Usage: Performs **GOSUB** or **GOTO** to a line number selected by a number expression.

Depending on the result of the expression, the target for **GOSUB** and **GOTO** is chosen from the table of line addresses at the end of the statement.

When used as a secondary keyword, **ON** is used in combination with primary keywords, such as **KEY** and **MOUSE**.

expression is a positive numeric value. Real values are converted to integer (losing precision). Logical operands are converted to a 16-bit integer, using $FFFF (decimal -1) for TRUE, and $0000 (decimal 0) for FALSE.

Remarks: Negative values for **expression** will stop the program with an error message. The **line number list** specifies the targets for values of 1, 2, 3, etc.
An expression result of zero, or a result that is greater than the number of target lines will not do anything, and the program will continue execution with the next statement.

Example: Using **ON**

```
 20 KEY   ON :REM ENABLE FUNCTION KEY STRINGS
 30 MOUSE ON :REM ENABLE MOUSE DRIVER
 40 N = JOY(1):IF N AND 128 THEN PRINT "FIRE! ";
 60 REM              N   NE  E   SE  S   SW  W   NW
 70 ON N AND 15 GOSUB 100,200,300,400,500,600,700,800
 80 GOTO 40
100 PRINT "GO NORTH"    :RETURN
200 PRINT "GO NORTHEAST":RETURN
300 PRINT "GO EAST"     :RETURN
400 PRINT "GO SOUTHEAST":RETURN
500 PRINT "GO SOUTH"    :RETURN
600 PRINT "GO SOUTHWEST":RETURN
700 PRINT "GO WEST"     :RETURN
800 PRINT "GO NORTHWEST":RETURN
```

OPEN

Format: **OPEN** channel, first address [, secondary address [, filename]]

Usage: Opens an input/output channel for a device.

channel number, where:

- **1 <= channel <= 127** line terminator is CR.
- **128 <= channel <= 255** line terminator is CR LF.

first address device number. For IEC devices the unit number is the primary address. Following primary address values are possible:

Unit	Device
0	Keyboard
1	System Default
2	RS232 Serial Connection
3	Screen
4 - 7	IEC Printer and Plotter
8 - 31	IEC Disk Drives

The **secondary address** has some reserved values for IEC disk units, 0: load, 1: save, 15: command channel. The values 2 - 14 may be used for disk files.

filename is either a quoted string, e.g. "DATA" or a string expression. The syntax is different to **DOPEN#**, since the **filename** for **OPEN** includes all file attributes, for example: "0:DATA,S,W".

Remarks: For IEC disk units the usage of **DOPEN#** is recommended.

If the first character of the filename is an at sign '@', it is interpreted as a "save and replace" operation. It is not recommended to use this option on 1541 and 1571 drives, as they contain a "save and replace bug" in their DOS.

Example: Using **OPEN**

```
OPEN 4,4   :REM OPEN PRINTER
CMD 4      :REM REDIRECT STANDARD OUTPUT TO 4
LIST       :REM PRINT LISTING ON PRINTER DEVICE 4
OPEN 3,8,3,"0:USER FILE,U"
OPEN 2,9,2,"0:DATA,S,W"
```

OR

Format: operand **OR** operand

Usage: Performs a bit-wise logical OR operation on two 16-bit values.

Integer operands are used as they are. Real operands are converted to a signed 16-bit integer (losing precision). Logical operands are converted to a 16-bit integer using $FFFF (decimal -1) for TRUE, and $0000 (decimal 0), for FALSE.

Expression	Result
0 OR 0	0
0 OR 1	1
1 OR 0	1
1 OR 1	1

Remarks: The result is of type integer. If the result is used in a logical context, the value of 0 is regarded as FALSE, and all other non-zero values are regarded as TRUE.

Example: Using **OR**

```
PRINT 1 OR 3
3
PRINT 128 OR 64
192
```

In most cases, **OR** is used in **IF** statements.

```
IF (C < 0 OR C > 255) THEN PRINT "NOT A BYTE VALUE"
```

PAINT

Format: **PAINT** x, y, mode [, region border colour]

Usage: Bitmap graphics: performs a flood fill of an enclosed graphics area using the current pen colour.

x, y is a coordinate pair, which must lie inside the area to be painted.

mode specifies the paint mode:

- **0** The colour of pixel (x,y) defines the colour, which is replaced by the pen colour.
- **1** The **region border colour** defines the region to be painted with the pen colour.
- **2** Paint the region connected to pixel (x,y).

region border colour defines the colour index for mode 1.

Example: Using **PAINT**

```
10 SCREEN 320,200,2     :REM OPEN SCREEN
20 PALETTE 0,1,10,15,10 :REM COLOUR 1 TO LIGHT GREEN
30 PEN 1                :REM SET DRAWING PEN (PEN 0) TO LIGHT GREEN (1)
40 LINE 160,0,240,100   :REM 1ST. LINE
50 LINE 240,100,80,100  :REM 2ND. LINE
60 LINE 80,100,160,0    :REM 3RD. LINE
70 PAINT 160,10         :REM FILL TRIANGLE WITH PEN COLOUR
80 GETKEY A&            :REM WAIT FOR KEY
90 SCREEN CLOSE         :REM END GRAPHICS
```

PALETTE

Format: **PALETTE** screen, colour, red, green, blue
PALETTE COLOR colour, red, green, blue
PALETTE RESTORE

Usage: **PALETTE** can be used to change an entry of the system colour palette, or the palette of a screen.
PALETTE RESTORE resets the system palette to the default values.

screen screen number (0 – 3).

COLOR keyword for changing system palette.

colour index to palette entry (0 – 255). PALETTE can define colours beyond the default system palette entries 0 – 31.

red red intensity (0 – 15).

green green intensity (0 – 15).

blue blue intensity (0 – 15).

Example: Using **PALETTE**

```
10 REM CHANGE SYSTEM COLOUR INDEX
20 REM --- INDEX  9 (BROWN) TO (DARK BLUE)
30 PALETTE COLOR 9,0,0,7
```

```
 10 GRAPHIC CLR             :REM INITIALISE
 20 SCREEN DEF 1,0,0,2      :REM 320 X 200
 30 SCREEN OPEN 1           :REM OPEN
 40 SCREEN SET 1,1          :REM MAKE SCREEN ACTIVE
 50 PALETTE 1,0,  0, 0, 0   :REM 0 = BLACK
 60 PALETTE 1,1, 15, 0, 0   :REM 1 = RED
 70 PALETTE 1,2,  0, 0,15   :REM 2 = BLUE
 80 PALETTE 1,3,  0,15, 0   :REM 3 = GREEN
 90 PEN 2                   :REM SET DRAWING PEN (PEN 0) TO BLUE (2)
100 LINE 160,0,240,100      :REM 1ST. LINE
110 LINE 240,100,80,100     :REM 2ND. LINE
120 LINE 80,100,160,0       :REM 3RD. LINE
130 PAINT 160,10,0,2        :REM FILL TRIANGLE WITH BLUE (2)
140 GETKEY K$               :REM WAIT FOR KEY
150 SCREEN CLOSE 1          :REM END GRAPHICS
```

PASTE

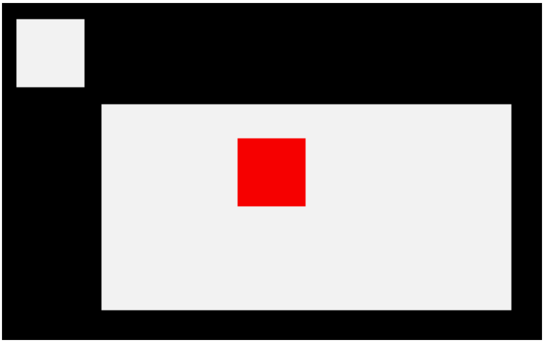
Format: **PASTE** x, y, width, height

Usage: Bitmap graphics: pastes the content of the **CUT** / **GCOPY** buffer onto the screen. The arguments upper left position **x, y** and the **width** and **height** specify the paste position on the screen.

Remarks: The size of the rectangle is limited by the 1K size of the buffer. The memory requirement for region is width * height * number of bit-planes / 8. It must not equal or exceed 1024 byte. For a 4-bitplane screen for example, a 45 x 45 region needs 1012.5 byte.

Example: Using **PASTE**

```
10 SCREEN 320,200,2
20 BOX 60,60,300,180,1  :REM DRAW A WHITE BOX
30 PEN 2                :REM SELECT RED PEN
40 CUT  140,80,40,40    :REM CUT OUT A 40 * 40 REGION
50 PASTE 10,10,40,40    :REM PASTE IT TO NEW POSITION
60 GETKEY A$            :REM WAIT FOR KEYPRESS
70 SCREEN CLOSE
```



PEEK

Format: **PEEK**(address)

Returns: The byte value stored in memory at **address**, as an unsigned 8-bit number.

If the address is in the range of \$0000 to \$FFFF (0 - 65535), the memory bank set by **BANK** is used.

Addresses greater than or equal to \$10000 (decimal 65536) are assumed to be flat memory addresses and used as such, ignoring the **BANK** setting.

Remarks: Banks 0 – 127 give access to RAM or ROM banks. Banks greater than 127 are used to access I/O, and the underlying system hardware such as the VIC, SID, FDC, etc.

Example: Using **PEEK**

```
10 BANK 128              :REM SELECT SYSTEM BANK
20 L = PEEK($02F8)       :REM USR JUMP TARGET LOW
30 H = PEEK($02F9)       :REM USR JUMP TARGET HIGH
40 T = L + 256 * H       :REM 16-BIT JUMP ADDRESS
50 PRINT "USR FUNCTION CALLS ADDRESS";T
```

PEN

Format: **PEN** [pen**,**] colour

Usage: Bitmap graphics: sets the colour of the graphic pen for the current screen.

pen pen number (0 – 2):

- **0** drawing pen (default, if only single parameter provided).
- **1** off bits in jam2 mode.
- **2** currently unused.

colour palette index, from the palette of the current screen

See appendix E on page 281 for the list of colours in the default system palette.

Remarks: The colour selected by **PEN** will be used by all graphic/drawing commands that follow it. If you intend to set the drawing **pen** 0 to a colour, you can omit the first parameter, and only provide the **colour** parameter.

Example: Using **PEN**

```
 10 GRAPHIC CLR            :REM INITIALISE
 20 SCREEN DEF 1,0,0,2     :REM 320 X 200
 30 SCREEN OPEN 1          :REM OPEN
 40 SCREEN SET 1,1         :REM MAKE SCREEN ACTIVE
 50 PALETTE 1,0,  0, 0, 0  :REM 0 = BLACK
 60 PALETTE 1,1, 15, 0, 0  :REM 1 = RED
 70 PALETTE 1,2,  0, 0,15  :REM 2 = BLUE
 80 PALETTE 1,3,  0,15, 0  :REM 3 = GREEN
 90 PEN 1                  :REM SET DRAWING PEN (PEN 0) TO RED (1)
100 LINE 160,0,240,100     :REM DRAW RED LINE
110 PEN 2                  :REM SET DRAWING PEN (PEN 0) TO BLUE (2)
120 LINE 240,100,80,100    :REM DRAW BLUE LINE
130 PEN 3                  :REM SET DRAWING PEN (PEN 0) TO GREEN (3)
140 LINE 80,100,160,0      :REM DRAW GREEN LINE
150 GETKEY K$              :REM WAIT FOR KEY
160 SCREEN CLOSE 1         :REM END GRAPHICS
```

PIXEL

Format: **PIXEL**(x, y)

Returns: Bitmap graphics: the colour of a pixel at the given position.

x absolute screen coordinate.

y absolute screen coordinate.

PLAY

Format: **PLAY** [{string1, string2, string3, string4, string5, string6}]

Usage: Starts playing a sequence of musical notes, or stops a currently playing sequence.

PLAY without any arguments will cause all voices to be silenced, and all of the music system's variables to be reset (such as **TEMPO**).

PLAY accepts up to six comma-separated string arguments, where each string describes the sequence of notes and directives to be played on a specific voice on the two available SID chips, allowing for up to 6-channel polyphony.

PLAY uses SID1 (for voices 1 to 3) and SID3 (for voices 4 to 6) of the 4 SID chips of the system. By default, SID1 and SID2 are slightly right-biased and SID3 and SID4 are slightly left-biased in the stereo mix.

```
PLAY "CEG"
PLAY "C","E","G"
```

Within a **PLAY** string, a musical note is a character (A, B, C, D, E, F, or G), which may be preceded by an optional modifier.

Possible modifiers are:

Character	Effect
#	Sharp
$	Flat
.	Dotted
W	Whole Note
H	Half Note
Q	Quarter Note
I	Eighth Note
S	Sixteenth Note
R	Pause (rest)

Notice that the dot (.) modifier appears before the note name, not after it as in traditional sheet music.

Directives consist of a letter, followed by a digit. Directives apply to all future notes, until the parameter is changed by another directive.

Character	Directive	Argument Range
O	Octave	0 – 6
T	Instrument Envelope	0 – 9
V	Volume	0 – 9
X	Filter	0 – 1
M	Modulation	0 – 9
P	Portamento	0 – 9
L	Loop	N/A

An octave is a range of notes from C to B. The default octave is 4, representing the "middle" octave.

Instrument envelopes describe the nature of the sound. See **ENVELOPE** for a list of default envelope styles, and information on how to adjust the ten envelopes.

The modulation directive adds a pitch-based vibrato your note by the magnitude you specify (1 – 9). A value of 0 disables it.

Similarly, the portamento directive slides between consecutive notes at the speed you specify (1 – 9). A value of 0 disables it. Note that the gate-off behaviour of notes is disabled while portamento is enabled. To re-enable the gate-off behavior, you must disable portamento (P0).

If a string ends with the **L** directive, the pattern loops back to the beginning of the string upon completion.

You can omit a string for a given voice to allow an already playing pattern in that voice to continue, using empty arguments:

```
PLAY "O4EDCDEEERL",,,"O2CGEGCGEGL"
```

An example using voice 2 and voice 5:

```
PLAY ,"O5T2IGAGFEDCEGO6.QCL",,,"O3T2.QG.B O4ICO3GE.QCL"
```

RPLAY(voice) tests whether music is playing on the given voice, and returns 1 if it is playing or 0 if it is not.

One caveat to be aware of is that BASIC strings have a maximum length of 255 bytes. If your melody needs to exceed this length, consider breaking up your melody into several strings, then use **RPLAY(voice)** to assess when your first string has finished and then play the next string.

Instrument envelope slots may be modified by using the **ENVELOPE** statement. The default settings for the envelopes are on page 146.

Remarks: The **PLAY** statement makes use of an interrupt driven routine that starts parsing the string and playing the melody. Program execution continues with the next statement, and will not block until the melody has finished. This is different to the Commodore 128, which stops program execution during playback.

The 6 voice channels used by the **PLAY** command (on SID1+SID3) are distinct to the 6 channels used by the **SOUND** command (on SID2+SID4). Sound effects will not interrupt music, and vice versa.

Example: Using **PLAY**

```
 5 REM *** SIMPLE LOOPING EXAMPLE ***
10 ENVELOPE 9,10,5,10,5,0,300
20 VOL 8,8
30 TEMPO 30
40 PLAY "O5T9HCIDCDEHCG IGAGFEFDEWCL", "O2T0QCGEGCGEG DBGB CGEGL"
```

```
 5 REM *** MODULATION + PORTAMENTO EXAMPLE ***
10 TEMPO 20
20 M$ = "M5 T205P0QD P5FP0RP5QG .AI#AQA HGQE.C IDQE HFQD .DI#CQD HEQ#CQ04HA"
30 M$ = M$ + "05QDHFQG.AI#AQA HGQE.C IDQEFED#C04B05#C D04AFD P0R L"
40 B$ = "T0QR02H.D.F.C01.A.#A.G.A QAI02AGFE H.D.F.C01.A.#A.A02 .D DL"
50 PLAY M$,B$
```

POINTER

Format: **POINTER**(variable)

Returns: The current address of a variable or an array element as a 32-bit pointer.

For string variables, it is the address of the string descriptor, not the string itself. The string descriptor consists of three bytes: length, string address low, string address high. The string address is an offset in bank 1.

For number-type scalar variables, it is the address of the value. The format depends on the type. A byte variable (`A&`) is one byte, in a "two's complement" signed integer format. An integer variable (`A%`) is two bytes, with the least significant byte first. A real variable (`A`) is five bytes, in a compact floating point number format.

To get the address of an array, use **POINTER** with the first element of the array (index 0 in each dimension). Array elements are stored consecutively, in the format of the scalar record, with the left-most index using the shortest stride. For example, an array dimensioned as `DIM A%(3,2)` starts at address `POINTER(A%(0,0))`, has two-byte records, and is ordered as:

(0,0) (1,0) (2,0) (3,0) (0,1) (1,1) (2,1) (3,1) ...

Remarks: The address values of arrays and their elements are constant while the program is executing.
However, the addresses of strings (not their descriptors) may change at any time due to "garbage collection."

Example: Using **POINTER**

```
10 BANK 0                :REM SCALARS ARE IN BANK 0
20 H$="HELLO"            :REM ASSIGN STRING TO H$
30 P=POINTER(H$)         :REM GET DESCRIPTOR ADDRESS
40 PRINT "DESCRIPTOR AT: $";HEX$(P)
50 L=PEEK(P):SP=WPEEK(P+1) :REM LENGTH & STRING POINTER
60 PRINT "LENGTH = ";L     :REM PRINT LENGTH
70 BANK 1                :REM STRINGS ARE IN BANK 1
80 FOR I%=0 TOL-1:PRINT PEEK(SP+I%);:NEXT:PRINT
90 FOR I%=0 TOL-1:PRINT CHR$(PEEK(SP+I%));:NEXT:PRINT

RUN
DESCRIPTOR AT: $FD75
LENGTH =  5
 72  69  76  76  79
HELLO
```

POKE

Format: **POKE** address, value [, value ...]

Returns: Writes one or more bytes into memory or memory mapped I/O, starting at **address**.

If the address is in the range of \$0000 to \$FFFF (0 - 65535), the memory bank set by **BANK** is used.

Addresses greater than or equal to \$10000 (decimal 65536) are assumed to be flat memory addresses and used as such, ignoring the **BANK** setting.

If **value** is in the range of 0 - 255, this is poked into memory, otherwise the low byte of value is used. So a command like `POKE AD,V AND 255` can be written as `POKE AD,V` because **POKE** uses the low byte anyway.

Remarks: The address is incremented for each data byte, so a memory range can be written to with a single **POKE**.

Banks greater than 127 are used to access I/O, and the underlying system hardware such as the VIC, SID, FDC, etc.

Example: Using **POKE**

```
10 BANK 128        :REM SELECT SYSTEM BANK
20 POKE $02F8,0,24 :REM SET USR VECTOR TO $1800
```

POLYGON

Format: **POLYGON** x, y, xrad, yrad, sides [{, drawsides, subtend, angle, solid}]

Usage: Bitmap graphics: draws a regular n-sided polygon. The polygon is drawn using the current drawing context set with **SCREEN**, **PALETTE**, and **PEN**.

x,y centre coordinates.

xrad,yrad radius in x- and y-direction.

sides number of polygon sides.

drawsides sides to draw.

subtend draw line from centre to start (1).

angle start angle.

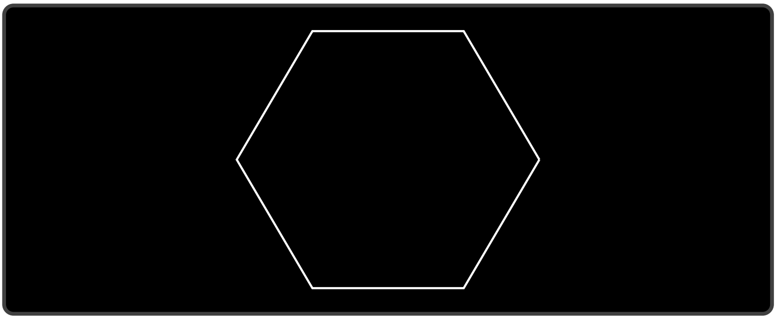
solid fill (1) or outline (0).

Remarks: A regular polygon is both isogonal and isotoxal, meaning all sides and angles are alike.

Example: Using **POLYGON**

```
100 SCREEN 320,200,1        :REM OPEN 320 x 200 SCREEN
110 POLYGON 160,100,40,40,6  :REM DRAW HONEYCOMB
120 GETKEY A$               :REM WAIT FOR KEY
130 SCREEN CLOSE            :REM CLOSE GRAPHICS SCREEN
```

Results in:



POS

Format: **POS**(dummy)

Returns: The cursor column relative to the currently used window.

dummy a numeric value, which is ignored.

Remarks: **POS** gives the column position for the screen cursor. It will not work for redirected output.

Example: Using **POS**

```
10 IF POS(0) > 72 THEN PRINT :REM INSERT RETURN
```

POT

Format: **POT**(paddle)

Returns: The position of a paddle peripheral.

paddle paddle number (1 – 4).

The low byte of the return value is the paddle value, with 0 at the clockwise limit and 255 at the anticlockwise limit.

A value greater than 255 indicates that the fire button is also being pressed.

Remarks: Analogue paddles are noisy and inexact. The range may be less than 0 – 255 and there could be some jitter in the values returned from **POT**.

Paddles made for Atari game consoles return different values from paddles made for Commodore computers. Commodore paddles provide more accurate values in the 0 – 255 range.

Example: Using **POT**

```
10 X = POT(1)       : REM READ PADDLE #1
20 B = X > 255      : REM TRUE (-1) IF FIRE BUTTON IS PRESSED
30 V = X AND 255    : REM PADDLE #1 VALUE
```

PRINT

Format: **PRINT** arguments

Usage: Prints a series of values formatted to the current output stream, typically the screen.

Values are formatted based on their type. For more control over formatting, see **PRINT USING**.

The following expressions and characters can appear in the argument list:

- **numeric** the printout starts with a space for positive and zero values, or a minus sign for negative values. Integer values are printed with the necessary number of digits. Real values are printed in either fixed point form (typically 9 digits), or scientific form if the value is outside the range of 0.01 to 999999999.
- **string** the string may consist of printable characters and control codes. Printable characters are printed at the cursor position. Control codes are executed.
- ; (semicolon) separates arguments of the list. It does not print any characters. A semicolon at the end of the argument list suppresses the automatic return (carriage return) character.
- , (comma) moves the cursor to the next tab position.

Remarks: The **SPC** and **TAB** functions may be used in the argument list for positioning.

CMD can be used to redirect printed characters to a device other than the screen.

Example: Using **PRINT**

```
10 FOR I=1 TO 10    : REM START LOOP
20 PRINT I,I*I,SQR(I)
30 NEXT
```

PRINT#

Format: **PRINT#** channel**,** arguments

Usage: Prints a series of values formatted to the device assigned to **channel**.

Values are formatted based on their type. For more control over formatting, see **PRINT# USING**.

channel number, which was given to a previous call to commands such as **APPEND**, **DOPEN**, or **OPEN**.

The following argument types are evaluated:

- **numeric** the printout starts with a space for positive and zero values, or a minus sign for negative values. Integer values are printed with the necessary number of digits. Real values are printed in either fixed point form (typically 9 digits), or scientific form if the value is outside the range of 0.01 to 999999999.

- **string** may consist of printable characters and control codes. Printable characters are printed at the cursor position, while control codes are executed.
- ; (semicolon) separates arguments of the list. It does not print any characters. A semicolon at the end of the argument list suppresses the automatic return (carriage return) character.
- , (comma) moves the cursor to the next tab position.

Remarks: The **SPC** and **TAB** functions are not suitable for devices other than the screen.

Example: Using **PRINT#** to write a file to drive 8:

```
10 DOPEN#2,"TABLE",W,U8
20 FOR I=1 TO 10    : REM START LOOP
30 PRINT#2,I,I*I,SQR(I)
40 NEXT
50 DCLOSE#2
```

You can confirm that the file **'TABLE'** has been written by typing `DIR "TA*"`, and then view the contents of the file by typing `TYPE "TABLE"`.

PRINT USING

Format: **PRINT**[**#** channel**,**] **USING** format**;** argument

Usage: Prints a series of values formatted using a pattern to the current output stream (typically the screen) or an output channel.

The argument can be either a string or a numeric value. The format of the resulting output is directed by the **format** string.

channel number, which was given to a previous call to commands such as **APPEND**, **DOPEN**, or **OPEN**. If no channel is specified, the output goes to the screen.

format string variable or a string constant which defines the rules for formatting. When using a number as the **argument**, formatting can be done in either CBM style, providing a pattern such as `###.##` or in C style using a <width.precision> specifier, such as `%3D %7.2F %4X` .

argument the number to be formatted. If the argument does not fit into the format e.g. trying to print a 4 digit variable into a series of three hashes (`###`), asterisks will be used instead.

Remarks: The format string is applied for one argument only, but it is possible to append more with **USING format;argument** sequences.

argument may consist of printable characters and control codes. Printable characters are printed to the cursor position, while control codes are executed. The number of # characters sets the width of the output. If the first character of the format string is an equals '=' sign, the argument string is centered. If the first character of the format string is a greater than '>' sign, the argument string is right justified.

Examples: Using **PRINT# USING**

```
PRINT USING "##.##";π, USING " [%6.4F] ";SQR(2)
 3.14 [1.4142]

PRINT USING " < # # # > ";12*31
 < 3 7 2 >

PRINT USING "###"; "ABCDE"
ABC

PRINT USING ">###"; "ABCDE"
CDE

PRINT USING "ADDRESS:$%4X";65000
ADDRESS:$FDE8

A$="####,####,####.#":PRINT USING A$;1E8/3
 33,333,333.3
```

RCOLOR

Format: **RCOLOR**(colour source)

Returns: The current colour index for the selected colour source.

Colour sources are:

- **0** background colour (VIC $D021).
- **1** text colour ($F1).
- **2** highlight colour ($2D8).
- **3** border colour (VIC $D020).

Example: Using **RCOLOR**

```
 10 C = RCOLOR(3)  : REM C = colour index of border colour
```

RCURSOR

Format: **RCURSOR** {colvar, rowvar}

Usage: Reads the current cursor column and row into variables.

Remarks: The row and column values start at zero, where the left-most column is zero, and the top row is zero.

Example: Using **RCURSOR**

```
100 CURSOR ON,20,10
110 PRINT "[HERE]";
120 RCURSOR X,Y
130 PRINT " COL:";X;" ROW:";Y

RUN

                    [HERE] COL: 26  ROW: 10
```

READ

Format: **READ** variable [, variable ...]

Usage: Reads values from **DATA** statements into variables.

variable list Any legal variables.

All types of constants (integer, real, and strings) can be read, but not expressions. Items are separated by commas. Strings containing commas, colons or spaces must be put in quotes.

RUN initialises the data pointer to the first item of the first **DATA** statement and advances it for every read item. It is the programmer's responsibility that the type of the constant and the variable in the **READ** statement match. Empty items with no constant between commas are allowed and will be interpreted as zero for numeric variables and an empty string for string variables.

RESTORE may be used to set the data pointer to a specific line for subsequent readings.

Remarks: It is good programming practice to put large amounts of **DATA** statements at the end of the program, so they don't slow down the search for line numbers after **GOTO**, and other statements with line number targets.

Example: Using **READ**

```
10 READ NA$, VE
20 READ N%:FOR I=2 TO N%:READ GL(I):NEXT I
30 PRINT "PROGRAM:";NA$;"   VERSION:";VE
40 PRINT "N-POINT GAUSS-LEGENDRE FACTORS E1":
50 FOR I=2 TO N%:PRINT I;GL(I):NEXT I
30 STOP
80 DATA "MEGA65",1.1
90 DATA 5,0.5120,0.3573,0.2760,0.2252
```

RECORD

Format: **RECORD#** channel**,** record [**,** byte]

Usage: Positions the read/write pointer of a relative file.

channel number, which was given to a previous call of commands such as **DOPEN**, or **OPEN**.

record target record (1 – 65535).

byte byte position in record.

RECORD can only be used for files of type **REL**, which are relative files capable of direct access.

RECORD positions the file pointer to the specified record number. If this record number does not exist and there is enough space on the disk which **RECORD** is writing to, the file is expanded to the requested record count by adding empty records. When this occurs, the disk status will give the message `RECORD NOT PRESENT`, but this is not an error!

After a call of **INPUT#** or **PRINT#**, the file pointer will proceed to the next record position.

Remarks: The Commodore disk drives have a bug in their DOS, which can destroy data by using relative files. A recommended workaround is to use the command **RECORD** twice, before and after the I/O operation.

Example: Using **RECORD**

```
100 DOPEN#2,"DATA BASE",L240 :REM OPEN OR CREATE
110 FOR I%=1 TO 20           :REM WRITE LOOP
120 PRINT#2,"RECORD #";I%    :REM WRITE RECORD
130 NEXT I%                  :REM END LOOP
140 DCLOSE#2                 :REM CLOSE FILE
150                          :REM NOW TESTING
160 DOPEN#2,"DATA BASE",L240 :REM REOPEN
170 FOR I%=20 TO 2 STEP -2   :REM READ FILE BACKWARDS
180 RECORD#2,I%              :REM POSITION TO RECORD
190 INPUT#2,A$               :REM READ RECORD
200 PRINT A$;:IF I% AND 2 THEN PRINT
210 NEXT I%                  :REM LOOP
220 DCLOSE#2                 :REM CLOSE FILE

RUN
RECORD # 20 RECORD # 18
RECORD # 16 RECORD # 14
RECORD # 12 RECORD # 10
RECORD # 8 RECORD # 6
RECORD # 4 RECORD # 2
```

REM

Format: **REM**

Usage: Ignores all subsequent characters on a line of BASIC code, as a code comment.

Example: Using **REM**

```
10 REM *** PROGRAM TITLE ***
20 N=1000 :REM NUMBER OF ITEMS
30 DIM NA$(N)
```

RENAME

Format: **RENAME** old **TO** new [**,D** drive] [**,U** unit]

Usage: Renames a disk file.

old is either a quoted string, e.g. `"DATA"` or a string expression in brackets, e.g. `(FI$)`.

new is either a quoted string, e.g. `"BACKUP"` or a string expression in brackets, e.g. `(FS$)`

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **RENAME** is executed in the DOS of the disk drive. It can rename all regular file types (**PRG**, **REL**), **SEQ**, **USR**. The old file must exist, and the new file must not exist. Only single files can be renamed, wildcard characters such as '*' and '?' are not allowed. The file type cannot be changed.

Example: Using **RENAME**

```
RENAME "CODES" TO "BACKUP" :REM RENAME SINGLE FILE
```

RENUMBER

Format: **RENUMBER** [{new**,** inc**,** range}]

Usage: Renumbers lines of a BASIC program.

new new starting line of the line range to renumber. The default value is 10.

inc increment to be used. The default value is 10.

range line range to renumber. The default values are from first to last line.

RENUMBER executes in either space conserving mode or optimisation mode. Optimisation mode removes space characters before line numbers, thereby reducing code size and decreasing execution time, while the space conserving leaves spaces untouched. Optimisation mode is triggered by typing the first argument, (the **new** starting number), adjacent to the keyword **RENUMBER** with no space in between.

RENUMBER changes all line numbers in the chosen range and also changes all references in statements that use **GOSUB**, **GOTO**, **RESTORE**, **RUN**, **TRAP**, etc.

RENUMBER can only be executed in direct mode. If it detects a problem such as memory overflow, unresolved references or line number overflow (more than than 64000 lines), it will stop with an error message and leave the program unchanged.

RENUMBER may be called with 0 - 3 parameters. Unspecified parameters use their default values.

Remarks: **RENUMBER** may need several minutes to execute for large programs.

RENUMBER can only be used in direct mode.

This command temporarily uses memory in banks 4 and 5, and may overwrite anything stored there.

Examples: Using **RENUMBER**

```
RENUMBER                :REM SPACE CONSERVING, NUMBERS WILL BE 10,20,30,...
RENUMBER 100,5          :REM SPACE CONSERVING, NUMBERS WILL BE 100,105,110,115,...
RENUMBER601,1,500       :REM OPTIMISATION, RENUMBER STARTING AT 500 TO 601,602,...
RENUMBER 100,5,120-180  :REM SPACE CONSERVING RENUMBER LINES 120-180 TO 100,105,...

10 GOTO  20
20 GOTO 10
RENUMBER 100,10         :REM SPACE CONSERVING
100 GOTO  110
110 GOTO 100
RENUMBER100,10          :REM OPTIMISATION
100 GOTO110
110 GOTO100
```

RESTORE

Format: **RESTORE** [line]

Usage: Sets the internal pointer for **READ** from **DATA** statements.

line new position for the pointer. The default is the first program line.

Remarks: The new pointer target **line** does not need to contain **DATA** statements. Every **READ** will advance the pointer to the next **DATA** statement automatically.

Example: Using **RESTORE**

```
10 DATA 3,1,4,1,5,9,2,6
20 DATA "MEGA65"
30 DATA 2,7,1,8,2,8,9,5
40 FOR I=1 TO 8:READ P:PRINT P:NEXT
50 RESTORE 30
60 FOR I=1 TO 8:READ P:PRINT P:NEXT
70 RESTORE 20
80 READ A$:PRINT A$
```

RESUME

Format: **RESUME** [line | **NEXT**]

Usage: Resumes normal program execution in a **TRAP** routine, after handling an error.

RESUME with no parameters attempts to re-execute the statement that caused the error. The **TRAP** routine should have examined and corrected the issue where the error occurred.

line line number to resume program execution at.

NEXT resumes execution following the statement that caused the error. This could be the next statement on the same line (separated with a colon ':'), or the statement on the next line.

Remarks: **RESUME** cannot be used in direct mode.

Example: Using **RESUME**

```
 10 TRAP 100
 20 FOR I=1 TO 100
 30 PRINT EXP(I)
 40 NEXT
 50 PRINT "STOPPED FOR I =";I
 60 END
100 PRINT ERR$(ER): RESUME 50
```

RETURN

Format: **RETURN**

Usage: Returns control from a subroutine that was called with **GOSUB** or an event handler declared with **COLLISION**.

The execution continues at the statement following the **GOSUB** call.

In the case of the **COLLISION** handler, the execution continues at the statement where it left from to call the handler.

Example: Using **RETURN**

```
 10 SCNCLR          :REM CLEAR SCREEN
 20 FOR I=1 TO 20   :REM DEFINE LOOP
 30 GOSUB 100       :REM CALL SUBROUTINE
 40 NEXT I          :REM LOOP
 50 END             :REM END OF PROGRAM
100 CURSOR ON,I,I,0 :REM ACTIVATE AND POSITION CURSOR
110 PRINT "X";      :REM PRINT X
120 SLEEP 0.5       :REM WAIT 0.5 SECONDS
130 CURSOR OFF      :REM SWITCH BLINKING CURSOR OFF
140 RETURN          :REM RETURN TO CALLER
```

RGRAPHIC

Format: **RGRAPHIC**(screen, parameter)

Returns: Bitmap graphics: the status of a given graphic screen parameter.

Parameter	Description
0	Open (1), Closed (0), or Invalid (>1)
1	Width (0=320, 1=640)
2	Height (0=200, 1=400)
3	Depth (1 – 8 Bitplanes)
4	Bitplanes Used (Bitmask)
5	Bank 4 Blocks Used (Bitmask)
6	Bank 5 Blocks Used (Bitmask)
7	Drawscreen # (0 – 3)
8	Viewscreen # (0 – 3)
9	Drawmodes (Bitmask)
10	pattern type (bitmask)

Example: Using **RGRAPHIC**

```
 10 GRAPHIC CLR         :REM INITIALISE
 20 SCREEN DEF 0,1,0,4  :REM SCREEN 0:640 X 200 X 4
 30 SCREEN OPEN 0       :REM OPEN
 40 SCREEN SET 0,0      :REM DRAW = VIEW = 0
 50 SCNCLR 0            :REM CLEAR
 60 PEN 0,1             :REM SELECT COLOUR
 70 LINE 0,0,639,199    :REM DRAW LINE
 80 FOR I=0 TO 10:A(I)=RGRAPHIC(0,I) :NEXT
 90 SCREEN CLOSE 0
100 FOR I=0 TO  6:PRINT I;A(I):NEXT :REM PRINT INFO

RUN
 0  1
 1  1
 2  0
 3  4
 4  15
 5  15
 6  15
```

RIGHT$

Format: **RIGHT$**(string, n)

Returns: A string containing the last **n** characters from **string**.

If the length of **string** is equal or less than **n**, the result string will be identical to the argument string.

string a string expression.

n a numeric expression (0 - 255).

Remarks: Empty strings and zero lengths are legal values.

Example: Using **RIGHT$**:

```
PRINT RIGHT$("MEGA-65",2)
65
```

RMOUSE

Format: **RMOUSE** x variable, y variable, button variable

Usage: Reads mouse position and button status.

x variable numeric variable where the x-position will be stored.

y variable numeric variable where the y-position will be stored.

button variable numeric variable receiving button status.
left button sets bit 7, while right button sets bit 0.

Coordinates are reported to be compatible with sprite coordinates, limited to the visible screen inside the border. In the top-left corner, X=24 and Y=50.

Value	Status
0	No Button
1	Right Button
128	Left Button
129	Both Buttons

RMOUSE places -1 into all variables if the mouse is not connected or disabled.

Remarks: Active mice on both ports merge the results.

Example: Using **RMOUSE**:

```
10 MOUSE ON, 1, 1        :REM MOUSE ON PORT 1 WITH SPRITE 1
20 RMOUSE XP, YP, BU     :REM READ MOUSE STATUS
30 IF XP < 0 THEN PRINT "NO MOUSE ON PORT 1":STOP
40 PRINT "MOUSE:";XP;YP;BU
50 MOUSE OFF             :REM DISABLE MOUSE
```

RND

Format: **RND**(type)

Returns: A pseudo-random number.

This is called a “pseudo-random” number as computers cannot generate numbers that are truly random. Pseudo-random numbers are derived mathematically from another number called a “seed” that generates reproducible sequences. **type** determines which seed is used:

- **type = 0** use system clock.
- **type < 0** use the value of **type** as seed.
- **type > 0** derive a new random number from previous one.

Remarks: Seeded random number sequences produce the same sequence for identical seeds.

The algorithm is initially seeded from the Real-Time Clock and other factors during boot, so `RND(1)` is unlikely to return the same sequence twice. This is unlike the Commodore 64, which always used the same initial seed. If **RND()** is ever called with a negative value, that value is used as a new seed, and sequences generated by `RND(1)` become predictable. Use `RND(0)` to re-seed with an unpredictable value.

Each call to `RND(0)` generates a new seed based on the system clock and other factors. Calling `RND(0)` repeatedly tends to produce a better distribution of values than on a Commodore 64 due to the precision of the sources of the seed.

Example: Using **RND**:

```
10 DEF FNDI(X) = INT(RND(0)*6)+1 :REM DICE FUNCTION
20 FOR I=1 TO 10                 :REM THROW 10 TIMES
30 PRINT I;FNDI(0)               :REM PRINT DICE POINTS
40 NEXT
```

RPALETTE

Format: **RPALETTE**(screen**,** index**,** rgb)

Returns: The red, green, or blue value of a palette colour index.

screen screen number (0 – 3), or a negative value to select one of the four system palettes: -1 for system palette 0 (the default system palette), -2 for system palette 1, -3 for palette 2, or -4 for palette 3.

index palette colour index.

rgb (0: red, 1: green, 2:blue).

Example: Using **RPALETTE**

```
10 SCREEN 320,200,4    :REM DEFINE AND OPEN SCREEN
20 R = RPALETTE(0,3,0) :REM GET RED
30 G = RPALETTE(0,3,1) :REM GET GREEN
40 B = RPALETTE(0,3,2) :REM GET BLUE
50 SCREEN CLOSE        :REM CLOSE SCREEN
60 PRINT "PALETTE INDEX 3 RGB =";R;G;B

RUN
PALETTE INDEX 3 RGB = 0  15  15
```

RPEN

Format: **RPEN**(n)

Returns: The colour index of pen **n**.

n pen number (0 – 2), where:

- 0 draw pen
- 1 erase pen
- 2 outline pen

Example: Using **RPEN**

```
 10 GRAPHIC CLR        :REM INITIALISE
 20 SCREEN DEF 0,1,0,4 :REM SCREEN 0:640 X 200 X 4
 30 SCREEN OPEN 0      :REM OPEN
 40 SCREEN SET 0,0     :REM DRAW = VIEW = 0
 50 SCNCLR 0           :REM CLEAR
 60 PEN 0,1            :REM SELECT COLOUR
 70 X = RPEN(0)
 80 Y = RPEN(1)
 90 C = RPEN(2)
100 SCREEN CLOSE 0
110 PRINT "DRAW PEN COLOUR = ";X
RUN
DRAW PEN COLOUR =  1
```

RPLAY

Format: **RPLAY**(voice)

Returns: Tests whether music is playing on the given voice channel.

voice the voice channel to assess, ranging from 1 to 6.

Returns 1 if music is playing on the channel, otherwise 0.

Example: Using **RPLAY**:

```
 10 PLAY "O4ICDEFGABO5CR","O2QCGEGCO1GCR"
 30 IF RPLAY(1) OR RPLAY(2) THEN GOTO 30: REM WAIT FOR END OF SONG
```

RREG

Format: **RREG** [{areg, xreg, yreg, zreg, sreg}]

Usage: Reads the values that were in the CPU registers after a **SYS** call, into the specified variables.

areg gets accumulator value.

xreg gets X register value.

yreg gets Y register value.

zreg gets Z register value.

sreg gets status register value.

Remarks: The register values after a **SYS** call are stored in system memory. This is how **RREG** is able to retrieve them.

Example: Using **RREG**:

```
10 POKE $1800, $18, $8A, $65, $06, $60
20 REM        CLC  TXA  ADC   06  RTS
30 SYS $1800, 77, 11  : REM A=77 X=11
40 RREG AC,X,Y,Z,S
50 PRINT "REGISTER:";AC;X;Y;Z;S
```

RSPCOLOR

Format: **RSPCOLOR**(n)

Returns: The colour setting of a multi-colour sprite colour.

n sprite multi-colour number:

- **1** get multi-colour # 1.
- **2** get multi-colour # 2.

Remarks: Refer to **SPRITE** and **SPRCOLOR** for more information.

Example: Using **RSPCOLOR**:

```
10 SPRITE 1,1         :REM TURN SPRITE 1 ON
20 C1% = RSPCOLOR(1)  :REM READ COLOUR #1
30 C2% = RSPCOLOR(2)  :REM READ COLOUR #2
```

RSPEED

Format: **RSPEED**(n)

Returns: The current CPU clock in MHz.

n numeric dummy argument, which is ignored.

Remarks: **RSPEED(n)** will not return the correct value if `POKE 0,65` has previously been used to enable the highest speed (40MHz).

Refer to the **SPEED** command for more information.

Example: Using **RSPEED**:

```
10 X=RSPEED(0)      :REM GET CLOCK
20 IF X=1  THEN PRINT "1 MHZ"   :GOTO 50
30 IF X=3  THEN PRINT "3.5 MHZ" :GOTO 50
40 IF X=40 THEN PRINT "40 MHZ"
50 END
```

RSPPOS

Format: **RSPPOS**(sprite, n)

Returns: A sprite's position or speed.

sprite sprite number.

n sprite parameter to retrieve:

- **0** X position.
- **1** Y position.
- **2** speed.

Remarks: Refer to the **MOVSPR** and **SPRITE** commands for more information.

Example: Using **RSPPOS**:

```
10 SPRITE 1,1         :REM TURN SPRITE 1 ON
20 XP = RSPPOS(1,0)   :REM GET X OF SPRITE 1
30 YP = RSPPOS(1,1)   :REM GET Y OF SPRITE 1
30 SP = RSPPOS(1,2)   :REM GET SPEED OF SPRITE 1
```

RSPRITE

Format: **RSPRITE**(sprite, n)

Returns: A sprite parameter.

sprite sprite number (0 – 7).

n the sprite parameter to return (0 - 5):

- **0** turned on (0 or 1) A 0 means the sprite is off.
- **1** foreground colour (0 - 15).
- **2** background priority (0 or 1).
- **3** x-expanded (0 or 1). 0 means it's not expanded.
- **4** y-expanded (0 or 1). 0 means it's not expanded.
- **5** multi-colour (0 or 1). 0 means it's not multi-colour.

Remarks: Refer to the **MOVSPR** and **SPRITE** commands for more information.

Example: Using **RSPRITE**:

```
10 SPRITE 1,1          :REM TURN SPRITE 1 ON
20 EN = RSPRITE(1,0)   :REM SPRITE 1 ENABLED ?
30 FG = RSPRITE(1,1)   :REM SPRITE 1 FOREGROUND COLOUR INDEX
40 BP = RSPRITE(1,2)   :REM SPRITE 1 BACKGROUND PRIORITY
50 XE = RSPRITE(1,3)   :REM SPRITE 1 X EXPANDED ?
60 YE = RSPRITE(1,4)   :REM SPRITE 1 Y EXPANDED ?
70 MC = RSPRITE(1,5)   :REM SPRITE 1 MULTI-COLOUR ?
```

RUN

Format: **RUN** [line number]
RUN filename [**,D** drive] [**,U** unit] ↑ filename

Usage: Runs the BASIC program in memory, or loads and runs a program from disk.

If a filename is given, the program file is loaded into memory and run, otherwise the program that is currently in memory will be used instead.

The ↑ can be used as shortcut, if used in direct mode at the leftmost column. It can be used to load and run a program from a dir listing by moving the cursor to the row with the filename, typing the ↑ at the start of the row and pressing return. Characters before and after the quoted filename, will be ignored (like the PRG for example).

line number an existing line number of the program in memory to run from.

filename either a quoted string, e.g. `"PROG"` or a string expression in brackets, e.g. `(PR$)`. The filetype must be **PRG**.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

RUN first resets all internal pointers to their default values. Therefore, there will be no variables, arrays or strings defined. The run-time stack is also reset, and the table of open files is cleared.

Remarks: To start or continue program execution without resetting everything, use **GOTO** instead.

Examples: Using **RUN**

```
RUN "FLIGHTSIM" :REM LOAD AND RUN PROGRAM FLIGHTSIM
RUN 1000        :REM RUN PROGRAM IN MEMORY, START AT LINE# 1000
RUN             :REM RUN PROGRAM IN MEMORY
```

RWINDOW

Format: **RWINDOW**(n)

Returns: A parameter of the current text window.

n the screen parameter to retrieve:

- **0** width of current text window.
- **1** height of current text window.
- **2** number of columns on screen (40 or 80).

Remarks: Older versions of **RWINDOW** reported the width – 1 and the height – 1 for arguments 0 and 1.

Refer to the **WINDOW** command for more information.

Example: Using **RWINDOW**:

```
10 W = RWINDOW(2)          :REM GET SCREEN WIDTH
20 IF W=80 THEN BEGIN      :REM IS 80 COLUMNS MODE ACTIVE?
30   PRINT CHR$(27)+"X";   :REM YES, SWITCH TO 40COLUMNS
40 BEND
```

SAVE

Format: **SAVE** filename [**,** unit]
[←] filename [**,** unit]

Usage: Saves a BASIC program to a file of type **PRG**.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

The maximum length of the filename is 16 characters, not counting the optional save and replace character '@' and the in-file drive definition. If the first character of the filename is an at sign '@', it is interpreted as a "save and replace" operation. It is not recommended to use this option on 1541 and 1571 drives, as they contain a "save and replace bug" in their DOS. The filename may be preceded by the drive number definition "0:" or "1:", which is only relevant for dual drive disk units.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **SAVE** is obsolete, implemented only for backwards compatibility. **DSAVE** should be used instead. The shortcut symbol [←] is next to [1]. Can only be used in direct mode.

Examples: Using **SAVE**

```
SAVE "ADVENTURE"
SAVE "ZORK-I",8
SAVE "1:DUNGEON",9
```

SAVEIFF

Format: **SAVEIFF** filename [**,D** drive] [**,U** unit]

Usage: Bitmap graphics: saves the current graphics screen to a disk file in **IFF** format.

The IFF (Interchange File Format) is supported by many different applications and operating systems. **SAVEIFF** saves the image, the palette and resolution parameters.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`. The maximum length of the filename is 16 characters. If the first character of the filename is an at sign '@' it is interpreted as a "save and replace" operation. It is not recommended to use this option on 1541 and 1571 drives, as they contain a ”save and replace bug” in their DOS.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: Files saved with **SAVEIFF** can be loaded with **LOADIFF**. Tools are available to convert popular image formats to IFF. These tools are available on several operating systems, such as Amiga OS, macOS, Linux, and Windows. For example, **ImageMagick** is a free graphics package that includes a tool called **convert**, which can be used to create IFF files in conjunction with the **ppmtoilbm** tool from the **Netbpm** package.

Example: Using **SAVEIFF**

```
10 SCREEN 320,200,2          :REM SCREEN #0 320 X 200 X 2
20 PEN 1                     :REM DRAWING PEN COLOUR 1 (WHITE)
30 LINE 25,25,295,175        :REM DRAW LINE
40 SAVEIFF "LINE-EXAMPLE",U8 :REM SAVE CURRENT VIEW TO FILE
50 SCREEN CLOSE              :REM CLOSE SCREEN AND RESTORE PALETTE
```

SCNCLR

Format: **SCNCLR** [colour]

Usage: Clears a text window or bitmap graphics screen.

SCNCLR (with no arguments) clears the current text window. The default window occupies the whole screen.

SCNCLR colour clears the graphic screen by filling it with the given **colour**.

Example: Using **SCNCLR**:

```
1 REM SCREEN EXAMPLE 2
10 GRAPHIC CLR          :REM INITIALISE
20 SCREEN DEF 1,0,0,2   :REM SCREEN #1 320 X 200 X 2
30 SCREEN OPEN 1        :REM OPEN SCREEN 1
40 SCREEN SET 1,1       :REM USE SCREEN 1 FOR RENDERING AND VIEWING
50 SCREEN CLR 0         :REM CLEAR SCREEN
60 PALETTE 1,1,15,15,15 :REM DEFINE COLOUR 1 AS WHITE
70 PEN 0,1              :REM DRAWING PEN
80 LINE 25,25,295,175   :REM DRAW LINE
90 SLEEP 10             :REM WAIT FOR 10 SECONDS
100 SCREEN CLOSE 1      :REM CLOSE SCREEN AND RESTORE PALETTE
```

SCRATCH

Format: **SCRATCH** filename [**,D** drive] [**,U** unit] [**,R**]

Usage: Erases ("scratches") a disk file.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

R Recover a previously erased file. This will only work if there were no write operations between erasure and recovery, which may have altered the contents of the disk.

Remarks: **SCRATCH filename** is a synonym of **ERASE filename** and **DELETE filename**.

In direct mode the success and the number of erased files is printed. The second to last number from the message contains the number of successfully erased files,

Examples: Using **SCRATCH**

```
SCRATCH "DRM",U9 :REM ERASE FILE DRM ON UNIT 9
01, FILES SCRATCHED,01,00
SCRATCH "OLD*"   :REM ERASE ALL FILES BEGINNING WITH "OLD"
01, FILES SCRATCHED,04,00
SCRATCH "R*=PRG" :REM ERASE PROGRAM FILES STARTING WITH 'R'
01, FILES SCRATCHED,09,00
```

SCREEN

Format: **SCREEN** [screen**,**] width**,** height**,** depth
SCREEN CLR colour
SCREEN DEF width flag**,** height flag**,** depth
SCREEN SET drawscreen**,** viewscreen
SCREEN OPEN [screen]
SCREEN CLOSE [screen]

Usage: Bitmap graphics: manages a graphics screen.

There are two approaches available when preparing the screen for the drawing of graphics: a simplified approach, and a detailed approach.

Simplified approach:

The first version of **SCREEN** (which has pixel units for width and height) is the easiest way to start a graphics screen, and is the preferred method if only a single screen is needed (i.e., a second screen isn't needed for double buffering). This does all of the preparatory work for you, and will call commands such as **GRAPHIC CLR**, **SCREEN CLR**, **SCREEN DEF**, **SCREEN OPEN** and, **SCREEN SET** on your behalf. It takes the following parameters:

SCREEN [screen,] width, height, depth

- **screen** the screen number (0 – 3) is optional. If no screen number is given, screen 0 is used. To keep this approach as simple as possible, it is suggested to use the default screen 0.
- **width** 320 or 640 (default 320)
- **height** 200 or 400 (default = 200)
- **depth** 1..8 (default = 8), colours = 2 ^depth.

The argument parser is error tolerant and uses default values for width (320) and height (200) if the parsed argument is not valid.

This version of **SCREEN** starts with a predefined palette and sets the background to black, and the pen to white, so drawing can start immediately using the default values.

On the other hand, the detailed approach will require the setting of palette colours and pen colour before any drawing can be done.

The **colour** value must be in the range of 0 to 15. See appendix E on page 281 for the list of colours in the default system palette.

When you are finished with your graphics screen, simply call **SCREEN CLOSE** [screen] to return to the text screen.

Detailed approach:

The other versions of **SCREEN** perform special actions, used for advanced graphics programs that open multiple screens, or require "double buffering". If you have chosen the simplified approach, you will not require any of these versions below, apart from **SCREEN CLOSE**.

SCREEN CLR colour (or **SCNCLR** colour)
Clears the active graphics screen by filling it with **colour**.

SCREEN DEF screen, width flag, height flag, depth
Defines resolution parameters for the chosen screen. The width flag and height flag indicate whether high resolution (1) or low resolution (0) is chosen.

- **screen** screen number 0 - 3
- **width flag** 0 - 1 (0:320, 1:640 pixel)
- **height flag** 0 - 1 (0:200, 1:400 pixel)
- **depth** 1 - 8 (2 - 256 colours)

Note that the width and height values here are **flags**, and **not pixel units**.

SCREEN SET drawscreen, viewscreen
Sets screen numbers (0 - 3) for the drawing and the viewing screen, i.e., while one screen is being viewed, you can draw on a separate screen and then later flip between them. This is what's known as double buffering.

SCREEN OPEN screen
Allocates resources and initialises the graphics context for the selected **screen** (0 - 3). An optional variable name as a further argument, gets the result of the command that can be tested afterwards for success.

SCREEN CLOSE [screen]
Closes **screen** (0 – 3) and frees resources. If no value is given, it will default to 0. Also note that upon closing a screen, **PALETTE RESTORE** is automatically performed for you.

Examples: Using **SCREEN**:

```
 5 REM *** SIMPLIFIED APPROACH ***
10 SCREEN 320,200,2    :REM SCREEN #0: 320 X 200 X 2
20 PEN 1               :REM DRAWING PEN COLOUR = 1 (WHITE)
30 LINE 25,25,295,175  :REM DRAW LINE
40 GETKEY A$           :REM WAIT KEYPRESS
50 SCREEN CLOSE        :REM CLOSE SCREEN 0 (RESTORE PALETTE)
```

```
  5 REM *** DETAILED APPROACH ***
 10 GRAPHIC CLR         :REM INITIALISE
 20 SCREEN DEF 1,0,0,2  :REM SCREEN #1: 320 X 200 X 2
 30 SCREEN OPEN 1       :REM OPEN SCREEN 1
 40 SCREEN SET 1,1      :REM USE SCREEN 1 FOR RENDERING AND VIEWING
 50 SCREEN CLR 0        :REM CLEAR SCREEN
 60 PALETTE 1,1,15,15,15:REM DEFINE COLOUR 1 AS WHITE
 70 PEN 0,1             :REM DRAWING PEN
 80 LINE 25,25,295,175  :REM DRAW LINE
 90 SLEEP 10            :REM WAIT 10 SECONDS
100 SCREEN CLOSE 1      :REM CLOSE SCREEN 1 (RESTORE PALETTE)
```

SET

Format:
SET DEF unit
SET DISK old **TO** new
SET VERIFY <**ON** | **OFF**>

Usage: **SET DEF** redefines the default unit for disk access, which is initialised to 8 by the DOS. Commands that do not explicitly specify a unit will use this default unit.

SET DISK is used to change the unit number of a disk drive temporarily.

SET VERIFY enables or disables the DOS verify-after-write mode for 3.5 drives.

Remarks: These settings are valid until a reset or shutdown.

Examples: Using **SET**:

```
DIR            :REM SHOW DIRECTORY OF UNIT 8
SET DEF 11     :REM UNIT 11 BECOMES DEFAULT
DIR            :REM SHOW DIRECTORY OF UNIT 11
DLOAD "*"      :REM LOAD FIRST FILE FROM UNIT 11
SET DISK 8 TO 9 :REM CHANGE UNIT# OF DISK DRIVE 8 TO 9
DIR U9         :REM SHOW DIRECTORY OF UNIT 9 (FORMER 8)
SET VERIFY ON  :REM ACTIVATE VERIFY-AFTER-WTITE MODE
```

SETBIT

Format: **SETBIT** address**,** bit number

Usage: Sets a single bit at the **address**.

If the address is in the range of $0000 to $FFFF (0 - 65535), the memory bank set by **BANK** is used.

Addresses greater than or equal to $10000 (decimal 65536) are assumed to be flat memory addresses and used as such, ignoring the **BANK** setting.

The **bit number** is a value in the range of 0 - 7.

A bank value > 127 is used to access I/O, and the underlying system hardware such as the VIC, SID, FDC, etc.

Example: Using **SETBIT**

```
10 BANK 128          :REM SELECT SYSTEM MAPPING
20 SETBIT $D011,6    :REM ENABLE EXTENDED BACKGROUND MODE
30 SETBIT $D01B,0    :REM SET BACKGROUND PRIORITY FOR SPRITE 0
```

SGN

Format: **SGN**(numeric expression)

Returns: The sign of a numeric expression, as a number.

- **-1** negative argument.
- **0** zero.
- **1** positive, non-zero argument.

Example: Using **SGN**

```
10 ON SGN(X)+2 GOTO 100,200,300 :REM TARGETS FOR MINUS,ZERO,PLUS
20 Z = SGN(X) * ABS(Y) : REM COMBINE SIGN OF X WITH VALUE OF Y
```

SIN

Format: **SIN**(numeric expression)

Returns: The sine of an angle.

The argument is expected in units of radians. The result is in the range (-1.0 to +1.0)

Remarks: A value in units of degrees can be converted to radians by multiplying it with $\pi/180$.

Examples: Using **SIN**

```
  PRINT SIN(0.7)
   .644217687

  X=30:PRINT SIN(X * π / 180)
   .5
```

SLEEP

Format: **SLEEP** seconds

Usage: Pauses execution for the given duration.

The argument is a positive floating point number of seconds. The precision is 1 microsecond.

Remarks: Pressing RUN STOP interrupts the sleep.

Example: Using **SLEEP**

```
20 SLEEP 10     :REM WAIT 10 SECONDS
40 SLEEP 0.0005 :REM SLEEP 500 MICRO SECONDS
50 SLEEP 0.01   :REM SLEEP  10 MILLI SECONDS
60 SLEEP DD     :REM TAKE SLEEP TIME FROM VARIABLE DD
70 SLEEP 600    :REM SLEEP 10 MINUTES
```

SOUND

Format: **SOUND** voice, freq, dur [{, dir, min, sweep, wave , pulse}]
SOUND CLR

Usage: **SOUND** plays a sound effect.

voice voice number (1 – 6).

freq frequency (0 – 65535).

dur duration in jiffies (0 – 32767). The duration of a jiffy depends on the display standard. There are 50 jiffies per second with PAL, 60 per second with NTSC.

dir direction (0:up, 1:down, 2:oscillate).

min minimum frequency (0 – 65535).

sweep sweep range (0 – 65535).

wave waveform (0:triangle, 1:sawtooth, 2:square, 3:noise).

pulse pulse width (0 – 4095).

SOUND CLR silences all sound from **SOUND** and **PLAY**, and resets the sound system and all parameters.

Remarks: **SOUND** starts playing the sound effect and immediately continues with the execution of the next BASIC statement while the sound effect is played. This enables the showing of graphics or text and playing sounds simultaneously.

SOUND uses SID2 (for voices 1 to 3) and SID4 (for voices 4 to 6) of the 4 SID chips of the system. By default, SID1 and SID2 are slightly right-biased and SID3 and SID4 are slightly left-biased in the stereo mix.

The 6 voice channels used by the **SOUND** command (on SID2+SID4) are distinct to the 6 channels used by the **PLAY** command (on SID1+SID3). Sound effects will not interrupt music, and vice versa.

Examples: Using **SOUND**

```
IF PEEK($D06F) AND $80 THEN J = 60: ELSE J = 50 :REM J IS JIFFIES PER SECOND
SOUND 1, 7382, J                :REM PLAY SQUARE WAVE ON VOICE 1 FOR 1 SECOND
SOUND 2,  800, J*60             :REM PLAY SQUARE WAVE ON VOICE 2 FOR 1 MINUTE
SOUND 3, 4000, 120, 2, 2000, 400, 1 :REM PLAY SWEEPING SAWTOOTH WAVE ON VOICE 3

SOUND CLR   :REM SILENCE SOUND, RESET PARAMETERS
```

SPC

Format: **SPC**(columns)

Returns: As an argument to **PRINT**, a string of cursor-right PETSCII codes, suitable for printing to advance the cursor the given number of columns.

Printing this is similar to pressing → **<column>** times.

This is not a real function and does not generate a string. It can only be used as an argument to **PRINT**.

Remarks: The name of this function is derived from “spaces,” which is misleading. The function prints **cursor right characters**, not spaces. The contents of those character cells that are skipped will not be changed.

Example: Using **SPC**

```
10 FOR I=8 TO 12
20 PRINT SPC(-(I<10));I :REM TRUE = -1, FALSE = 0
30 NEXT I
RUN
 8
 9
10
11
12
```

SPEED

Format: **SPEED** [speed]

Usage: Sets the CPU clock speed to 1MHz, 3.5MHz, or 40MHz.

speed CPU clock speed where:

- **1** sets CPU to 1MHz.
- **3** sets CPU to 3MHz.
- Anything other than **1** or **3** sets the CPU to 40MHz.

Remarks: Although it’s possible to call **SPEED** with any real number, the precision part (the decimal point and any digits after it), will be ignored.

SPEED is a synonym of **FAST**.

SPEED has no effect if `POKE 0,65` has previously been used to set the CPU to 40MHz.

Example: Using **SPEED**

```
10 SPEED     :REM SET SPEED TO MAXIMUM (40 MHZ)
20 SPEED 1   :REM SET SPEED TO 1 MHZ
30 SPEED 3   :REM SET SPEED TO 3.5 MHZ
40 SPEED 3.5 :REM SET SPEED TO 3.5 MHZ
```

SPRCOLOR

Format: **SPRCOLOR** [{mc1**,** mc2}]

Usage: Sets multi-colour sprite colours.

SPRITE, which sets the attributes of a sprite, only sets the foreground colour. For setting the additional two colours of multi-colour sprites, use **SPRCOLOR** instead.

Remarks: The colours used with **SPRCOLOR** will affect all sprites. Refer to the **SPRITE** command for more information.

The final argument to **SPRITE** enables multi-colour mode for the sprite.

Example: Using **SPRCOLOR**:

```
10 SPRITE 1,1,2,,,,1  :REM TURN SPRITE 1 ON (FG = 2)
20 SPRCOLOR 4,5       :REM MC1 = 4, MC2 = 5
```

SPRITE

Format: **SPRITE CLR**
SPRITE LOAD filename [**,D** drive] [**,U** unit]
SPRITE SAVE filename [**,D** drive] [**,U** unit]
SPRITE num [{, switch, colour, prio, expx, expy, mode}]

Usage: **SPRITE CLR** clears all sprite data and sets all pointers and attributes to their default values.

SPRITE LOAD loads sprite data from **filename** to sprite memory.

SPRITE SAVE saves sprite data from sprite memory to **filename**.

filename the name of a file. Either a quoted string such as `"DATA"`, or a string expression in brackets such as `(FI$)`.

The last form switches a sprite on or off and sets its attributes:

num sprite number

switch 1: on, 0: off

colour sprite foreground colour

prio 0: sprite in front of text, 1: sprite behind text

expx 1: sprite X expansion

expy 1: sprite Y expansion

mode 1: multi-colour sprite

Remarks: **SPRCOLOR** must be used to set additional colours for multi-colour sprites (mode = 1).

Example: Using **SPRITE**:

```
2290 CLR:SCNCLR:SPRITE CLR
2300 SPRITE LOAD "DEMOSPRITES1"
2320 FORI=0TO7: C=I: IFC=6THENC=8
2330 MOVSPR I, 60+30*I,0 TO 60+30*I,65+20*I, 3:SPRITE I,1,C,,1,1:NEXT: SLEEP3
2340 FORI=0TO7: SPRITE I,,,,0,0 :NEXT: SLEEP3: SPRITE CLR
2350 FORI=0TO7: MOVSPR I,45*I#5 :NEXT: FORI=0TO7: SPRITE I,1: NEXT
2360 FORI=0TO7:X=60+30*I:Y=65+20*I:DO
2370 LOOPUNTIL(X=RSPPOS(I,.))AND(Y=RSPPOS(I,1)):MOVSPRI,.#.:NEXT
```

SPRSAV

Format: **SPRSAV** source, destination

Usage: Copies sprite data between two sprites, or between a sprite and a string variable.

source sprite number or string variable.

destination sprite number or string variable.

Remarks: Source and destination can either be a sprite number or a string variable,

SPRSAV can be used with the basic form of sprites (C64 compatible) only. These sprites occupy 64 bytes of memory, and create strings of length 64, if the destination parameter is a string variable.

Extended sprites and variable height sprites cannot be used with **SPRSAV**.

A string array of sprite data can be used to store many shapes and copy them fast to the sprite memory with the command **SPRSAV**.

It's also a convenient method to read or write shapes of single sprites from or to a disk file.

Example: Using **SPRSAV**:

```
10 SPRITE LOAD "SPRITEDATA" :REM LOAD DATA FOR 8 SPRITES
20 SPRITE 1,1               :REM TURN SPRITE 1 ON
30 SPRSAV 1,2               :REM COPY SPRITE 1 DATA TO SPRITE 2
40 SPRITE 2,1               :REM TURN SPRITE 2 ON
50 SPRSAV 1,A$              :REM SAVE SPRITE 1 DATA IN STRING A$
```

SQR

Format: **SQR**(numeric expression)

Returns: The square root of a numeric expression.

Remarks: The argument must not be negative.

Example: Using **SQR**

```
PRINT SQR(2)
 1.41421356
```

ST

Format: **ST**

Usage: The status of the last I/O operation.

If **ST** is zero, there was no error, otherwise it is set to a device dependent error code.

Remarks: **ST** is a reserved system variable.

Example: Using **ST**

```
100 MX=100:DIM T$(MX)        :REM DATA ARRAY
110 DOPEN#1,"DATA"           :REM OPEN FILE
120 IF DS THEN PRINT"COULD NOT OPEN":STOP
130 LINE INPUT#1,T$(N):N=N+1  :REM READ ONE RECORD
140 IF N>MX THEN PRINT "TOO MANY DATA":GOTO 160
150 IF ST=0 THEN 130         :REM ST = 64 FOR END-OF-FILE
160 DCLOSE#1
170 PRINT "READ";N;" RECORDS"
```

STEP

Format: **FOR** index = start **TO** end [**STEP** step] ... **NEXT** [index]

Usage: **STEP** is an optional part of a **FOR** loop.

The **index** variable may be incremented or decremented by a constant value after each iteration. The default is to increment the variable by 1. The index variable must be a real variable.

start initial value of the index.

end is checked at the end of an iteration, and determines whether another iteration will be performed, or if the loop will exit.

step defines the change applied to to the **index** at the end of a loop iteration. Positive step values increment it, while negative values decrement it. It defaults to 1.0 if not specified.

Remarks: For positive increments, **end** must be greater than or equal to **start**. For negative increments, **end** must be less than or equal to **start**.

It is bad programming practice to change the value of the **index** variable inside the loop or to jump into or out of a loop body with **GOTO**.

Example: Using **STEP**

```
10 FOR D=0 TO 360 STEP 30
20 R = D * π / 180
30 PRINT D;R;SIN(R);COS(R);TAN(R)
40 NEXT D
```

STOP

Format: **STOP**

Usage: Stops the execution of the BASIC program.

A message will be displayed showing the line number where the program stopped. The `READY.` prompt appears and the computer goes into direct mode, waiting for keyboard input.

Remarks: All variable definitions are still valid after **STOP**. They may be inspected or altered, and the program may be continued with **CONT**. However, any editing of the program source will disallow any further continuation.

Program execution can be resumed with **CONT**.

Example: Using **STOP**

```
10 IF V < 0 THEN STOP : REM NEGATIVE NUMBERS STOP THE PROGRAM
20 PRINT SQR(V)       : REM PRINT SQUARE ROOT
```

STR$

Format: **STR$**(numeric expression)

Returns: A string of the formatted value of the argument, as if it were **PRINT**ed to the string.

Example: Using **STR$**:

```
A$ = "THE VALUE OF PI IS " + STR$(π)
PRINT A$
THE VALUE OF PI IS 3.14159265
```

STRBIN$

Format: **STRBIN$**(numeric expression)

Returns: The number value as a string of its binary representation.

Example: Using **STRBIN$**:

```
PRINT STRBIN$(245)
11110101
```

SYS

Format: **SYS** address [{, areg, xreg, yreg, zreg, sreg}]

Usage: Calls a machine language subroutine.

address start address of the subroutine. This can be a ROM-resident KERNAL routine or any other routine which has previously been loaded or **POKE**d to RAM.

areg CPU accumulator value.

xreg CPU X register value.

yreg CPU Y register value.

zreg CPU Z register value.

sreg Status register value.

SYS loads the arguments (if any) into registers, then calls the subroutine. The called routine must exit with an **RTS** instruction. After the subroutine has returned, it saves the new register contents, then returns control to the BASIC program.

If the address value is 16 bit ($0000 - $FFFF), the **BANK** value is used to determine the actual address. If the address is higher than $FFFF, it is interpreted as a linear 24 bit address and the value of **BANK** is ignored.

Unlike other BASIC commands that access memory, there are restrictions on which addresses **SYS** can access:

- **SYS** can only access banks 0 – 5, and cannot access Attic RAM or upper memory, even when using long addresses.
- Only offsets $2000 – $7FFF within a given bank actually refer to the memory of that bank.
- **SYS** can only access offsets $0000 – $1FFF in bank 0.
- Accessing offsets $8000 – $FFFF always accesses memory as if **BANK** is set to 128 (including ROM and I/O register mappings), even when **BANK** is set to a different bank or when using long addresses.

Remarks: The register values after a **SYS** call are stored in system memory. **RREG** can be used to retrieve these values.

Despite the unusual restrictions on addresses, the **SYS** command is a powerful way to combine BASIC and machine language code. For short routines, memory in bank 0 offsets $1800 – $1EFF are available for program use. If care is taken to avoid overwriting the end of the BASIC program, machine language routines can be loaded elsewhere in bank 0 up to offset $BFFF.

Using **SYS** properly (i.e. without corrupting the system) requires some technical skill, which is out of scope of the User's Guide. For more information and examples, see the "Memory" chapter of the **MEGA65 Book**.

Example: Using **SYS**:

```
10 REM DEMO FOR SYS:CHANGING THE BORDER COLOUR
20 BANK 0
30 POKE $4000,$EE,$20,$D0,$60 :REM INC $D020:RTS
40 SYS $4000                  :REM CALL SUBROUTINE AT $4000 / BANK $00
50 GETKEY A$:IF A$ <> "Q" THEN 40
```

TAB

Format: **TAB**(column)

Returns: Positions the cursor at **column**.

This is only done if the target column is *right* of the current cursor column, otherwise the cursor will not move. The column count starts with 0 being the left-most column.

Remarks: This function shouldn't be confused with TAB, which advances the cursor to the next tab-stop.

Example: Using **TAB**

```
10 FOR I=1 TO 5
20 READ A$
30 PRINT "* " A$ TAB(10) " *"
40 NEXT I
50 END
60 DATA ONE,TWO,THREE,FOUR,FIVE

RUN
* ONE      *
* TWO      *
* THREE    *
* FOUR     *
* FIVE     *
```

TAN

Format: **TAN**(numeric expression)

Returns: The tangent of an angle.

The argument is expected in units of radians. The result is in the range (-1.0 to +1.0)

Remarks: A value in units of degrees can be converted to radians by multiplying it with $\pi/180$.

Example: Using **TAN**

```
PRINT TAN(0.7)
 .84228838

X=45:PRINT TAN(X * π / 180)
 .99999999
```

TEMPO

Format: **TEMPO** speed

Usage: Sets the playback speed for **PLAY**.

speed 1 - 255

The duration (in seconds) of a whole note is computed with $duration = 24/speed$.

Example: Using **TEMPO**

```
10 VOL 8,8
20 FOR T = 24 TO 18 STEP -2
30 TEMPO T
40 PLAY "T0M3O4QGAGFED","T2O4M5P0H.DP5GB","T5O3IGAGAGAABABAB"
50 IF RPLAY(1) THEN GOTO 50
60 NEXT T
70 PLAY "T0O5QCO4GEH.C","T2O5IEFEDEDCEGO6P8CP0R","T5O3ICDCDEFEDCO4C"
```

THEN

Format: **IF** expression **THEN** true clause [**ELSE** false clause]

Usage: **THEN** is part of an **IF** statement.

expression is a logical or numeric expression. A numeric expression is evaluated as **FALSE** if the value is zero and **TRUE** for any non-zero value.

true clause one or more statements starting directly after **THEN** on the same line. A line number after **THEN** performs a **GOTO** to that line instead.

false clause one or more statements starting directly after **ELSE** on the same line. A linenumber after **ELSE** performs a **GOTO** to that line instead.

Remarks: The standard **IF ... THEN ... ELSE** structure is restricted to a single line. But the **true clause** and **false clause** may be expanded to several lines using a compound statement surrounded with **BEGIN** and **BEND**.

Example: Using **THEN**

```
1 REM THEN
10 RED$=CHR$(28) : BLACK$=CHR$(144) : WHITE$=CHR$(5)
20 INPUT "ENTER A NUMBER";V
30 IF V<0 THEN PRINT RED$; : ELSE PRINT BLACK$;
40 PRINT V : REM PRINT NEGATIVE NUMBERS IN RED
50 PRINT WHITE$
60 INPUT "END PROGRAM: (Y/N)"; A$
70 IF A$="Y" THEN END
80 IF A$="N" THEN 20 : ELSE 60
```

TI

Format: **TI**

Usage: A high precision timer variable with a resolution of 1 micro second.

It is started or reset with **CLR TI**, and can be accessed in the same way as any other variable in expressions.

Remarks: **TI** is a reserved system variable. The value in **TI** is the number of seconds (to 6 decimal places) since it was last cleared or started.

Example: Using **TI**

```
100 CLR TI                 :REM START TIMER
110 FOR I%=1 TO 10000:NEXT :REM DO SOMETHING
120 ET = TI                :REM STORE ELAPSED TIME IN ET
130 PRINT "EXECUTION TIME:";ET;" SECONDS"
```

TI$

Format: **TI$**

Usage: The current time of day, as a string.

The time value is updated from the RTC (Real-Time Clock). The string **TI$** is formatted as: "hh:mm:ss".

TI$ is a read-only variable, which reads the registers of the RTC and formats the values to a string. This differs from other Commodore computers that do not have an RTC.

Remarks: **TI$** is a reserved system variable.

It is possible to access the RTC registers directly via **PEEK**. The start address of the registers is at $FFD7110.

For more information on how to set the Real-Time Clock, refer to the Configuration Utility section on page the **MEGA65 Book**.

```
100 REM ****** READ RTC ****** ALL VALUES ARE BCD ENCODED
110 RT = $FFD7110              :REM ADDRESS OF RTC
120 FOR I=0 TO 5               :REM SS,MM,HH,DD,MO,YY
130 T(I)=PEEK(RT+I)            :REM READ REGISTERS
140 NEXT I                     :REM USE ONLY LAST TWO DIGITS
150 T(2) = T(2) AND 127        :REM REMOVE 24H MODE FLAG
160 T(5) = T(5) + $2000        :REM ADD YEAR 2000
170 FOR I=2 TO 0 STEP -1       :REM TIME INFO
180 PRINT USING ">## ";HEX$(T(I));
190 NEXT I
RUN
12 52 36
```

Example: Using **TI$**

```
PRINT DT$;TI$
05-APR-2021 15:10:00
```

TO

Format: keyword **TO**

Usage: **TO** is a secondary keyword used in combination with primary keywords, such as **BACKUP**, **BSAVE**, **CHANGE**, **CONCAT**, **COPY**, **FOR**, **GO**, **RENAME**, and **SET DISK**

Remarks: **TO** cannot be used on its own.

Example: Using **TO**

```
10 GO TO 1000    :REM AS GOTO 1000
20 GOTO 1000     :REM SHORTER AND FASTER
30 FOR I=1 TO 10 :REM TO IS PART OF THE LOOP
40 PRINT I:NEXT  :REM LOOP END
50 COPY "CODES" TO "BACKUP" :REM COPY SINGLE FILE
```

TRAP

Format: **TRAP** [line number]

Usage: Registers (or clears) a BASIC error handler subroutine.

With an error handler registered, when a BASIC program encounters an error, it calls the subroutine instead of exiting the program. During the subroutine, the system variable **ER** contains the error number. The **TRAP** error handler can then decide whether to **STOP** or **RESUME** execution.

TRAP with no argument disables the error handler, and errors will then be handled by the normal system routines.

Example: Using **TRAP**

```
 10 TRAP 100
 20 FOR I=1 TO 100
 30 PRINT EXP(I)
 40 NEXT
 50 PRINT "STOPPED FOR I =";I
 60 END
100 PRINT ERR$(ER): RESUME 50
```

TROFF

Format: **TROFF**

Usage: Turns off trace mode (switched on by **TRON**).

When trace mode is active, each line number is printed before it is executed. **TROFF** turns off trace mode.

Example: Using **TROFF**

```
 10 TRON            :REM ACTIVATE TRACE MODE
 20 FOR I=85 TO 100
 30 PRINT I;EXP(I)
 40 NEXT
 50 TROFF           :REM DEACTIVATE TRACE MODE

RUN
[10][20][30] 85  8.22301268E+36
[40][30] 86  2.2352466E+37
[40][30] 87  6.0760302E+37
[40][30] 88  1.65163625E+38
[40][30] 89
?OVERFLOW ERROR IN 30
READY.
```

TRON

Format: **TRON**

Usage: Turns on trace mode.

When trace mode is active, each line number is printed before it is executed. **TRON** turns on trace mode.

This is useful for debugging the control flow of a BASIC program. To use it, add **TRON** and **TROFF** statements to the program around the lines that need debugging.

Example: Using **TRON**


```
 10 TRON            :REM ACTIVATE TRACE MODE
 20 FOR I=85 TO 100
 30 PRINT I;EXP(I)
 40 NEXT
 50 TROFF           :REM DEACTIVATE TRACE MODE

RUN
[10][20][30] 85  8.22301268E+36
[40][30] 86  2.2352466E+37
[40][30] 87  6.0760302E+37
[40][30] 88  1.65163625E+38
[40][30] 89
?OVERFLOW ERROR IN 30
READY.
```

TYPE

Format: **TYPE** [**P**] filename [**,D** drive] [**,U** unit]

Usage: Prints the contents of a file containing text encoded as PETSCII.

If the **P** flag is specified, the listing will pause for each screenful of text. Pressing **Q** quits page mode, while any other key continues to the next page.

filename the name of a file. Either a quoted string such as "DATA", or a string expression in brackets such as (FI$).

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **TYPE** cannot be used to print BASIC programs. Use **LIST** for programs instead. **TYPE** can only process **SEQ** or **USR** files containing records of PETSCII text, delimited by the CR character. (The CR (carriage return) character can be written to a file using **CHR$(13)**.)

See the **EDIT** command for a way to create and modify text files interactively with the MEGA65.

Example: Using **TYPE**

```
TYPE "README"
TYPE "README 1ST",U9

TYPE P "MOBYDICK"
```

UNLOCK

Format: **UNLOCK** filename/pattern [**,D** drive] [**,U** unit]

Usage: Unlocks a locked file on disk.

The specified file or a set of files, that matches the pattern, is unlocked and no more protected. It can be deleted afterwards with the commands **DELETE**, **ERASE** or **SCRATCH**

The **LOCK** command locks a file.

filename the name of a file. Either a quoted string such as "DATA", or a string expression in brackets such as (FI$).

drive drive # in dual drive disk units.
The drive # defaults to **0** and can be omitted on single drive units such as the 1541, 1571, or 1581.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: Unlocking a file that is already unlocked has no effect.

In direct mode the number of unlocked files is printed. The second to last number from the message contains the number of unlocked files,

Examples: Using **UNLOCK**

```
UNLOCK "SNOOPY",U9 :REM UNLOCK FILE SNOOPY ON UNIT 9
03,FILES UNLOCKED,01,00
UNLOCK "BS*"    :REM UNLOCK ALL FILES BEGINNING WITH "BS"
03,FILES UNLOCKED,04,00
```

UNTIL

Format: **DO** ... **LOOP**
DO [<**UNTIL** | **WHILE**> logical expression]
. . . statements [**EXIT**]
LOOP [<**UNTIL** | **WHILE**> logical expression]

Usage: **DO** and **LOOP** define the start of a BASIC loop. Using **DO** and **LOOP** alone without any modifiers creates an infinite loop, which can only be exited by the **EXIT** statement. The loop can be controlled by adding **UNTIL** or **WHILE** after the **DO** or **LOOP**.

Remarks: **DO** loops may be nested. An **EXIT** statement exits the current loop only.

Examples: Using **DO** and **LOOP**.

```
10 PW$="":DO
20 GET A$:PW$=PW$+A$
30 LOOP UNTIL LEN(PW$)>7 OR A$=CHR$(13)

10 DO : REM WAIT FOR USER DECISION
20 GET A$
30 LOOP UNTIL A$="Y" OR A$="N" OR A$="y" OR A$="n"

10 DO WHILE ABS(EPS) > 0.001
20 GOSUB 2000 : REM ITERATION SUBROUTINE
30 LOOP

10 I%=0 : REM INTEGER LOOP 1-100
20 DO I%=I%+1
30 LOOP WHILE I% < 101
```

USING

Format: **PRINT**[# channel**,**] **USING** format**;** argument

Usage: Parses the **format** string and evaluates the argument. The argument can be either a string or a numeric value. The format of the resulting output is directed by the **format** string.

channel number, which was given to a previous call to commands such as **APPEND**, **DOPEN**, or **OPEN**. If no channel is specified, the output goes to the screen.

format string variable or a string constant which defines the rules for formatting. When using a number as the **argument**, formatting can be done in either CBM style, providing a pattern such as `###.##` or in C style using a <width.precision> specifier, such as `%3D %7.2F %4X` .

argument the number to be formatted. If the argument does not fit into the format e.g. trying to print a 4 digit variable into a series of three hashes (`###`), asterisks will be used instead.

Remarks: The format string is only applied for one argument, but it is possible to append more than one **USING format;argument** sequences.

argument may consist of printable characters and control codes. Printable characters are printed to the cursor position, while control codes are executed. The number of `#` characters sets the width of the output. If the first character of the format string is an equals '=' sign, the argument string is centered. If the first character of the format string is a greater than '>' sign, the argument string is right justified.

Example: **USING** with a corresponding **PRINT#**

```
PRINT USING "##.##";π, USING " [%6.4F] ";SQR(2)
 3.14 [1.4142]

PRINT USING " < # # # > ";12*31
 < 3 7 2 >

PRINT USING "###"; "ABCDE"
ABC

PRINT USING ">###"; "ABCDE"
CDE

PRINT USING "ADDRESS:$%4X";65000
ADDRESS:$FDE8

A$="####,####,####.#":PRINT USING A$;1E8/3
 33,333,333.3
```

USR

Format: **USR**(numeric expression)

Usage: Invokes an assembly language routine whose memory address is stored at $02F8 – $02F9.

The result of the **numeric expression** is written to floating point accumulator 1.

After executing the assembly routine, BASIC returns the contents of the floating point accumulator 1.

Remarks: Banks 0 – 127 give access to RAM or ROM banks. Banks greater than 127 are used to access I/O, and the underlying system hardware such as the VIC, SID, FDC, etc.

The floating point accumulator is a facility of the KERNAL that is outside the scope of the User's Guide.

Example: Using **USR**

```
10 WPOKE $2F8, $7F33  : REM NEGATE ROUTINE
20 PRINT USR(π)
30 PRINT USR(-5)
```

VAL

Format: **VAL**(string expression)

Returns: The decimal floating point value represented by a string.

Remarks: **VAL** parses characters from the beginning of the string that resemble a BASIC decimal number, including a leading negative sign, digits, a decimal point, and an exponent. If it encounters an invalid character, it stops parsing and returns the result up to that point in the string.

Example: Using **VAL**

```
PRINT VAL("78E2")
7800

PRINT VAL("7+5")
7

PRINT VAL("1.256")
1.256

PRINT VAL("$FFFF")
0
```

VERIFY

Format: **VERIFY** filename [, unit [, binflag]]

Usage: **VERIFY** with no **binflag** compares a BASIC program in memory with a disk file of type **PRG**. It does the same as **DVERIFY**, but the syntax is different.

VERIFY with **binflag** compares a binary file in memory with a disk file of type **PRG**. It does the same as **BVERIFY**, but the syntax is different.

filename is either a quoted string, e.g. `"PROG"` or a string expression.

unit device number on the IEC bus. Typically in the range from 8 to 11 for disk units. If a variable is used, it must be placed in brackets. The unit # defaults to **8**.

Remarks: **VERIFY** can only test for equality. It gives no information about the number or position of different valued bytes. **VERIFY** exits with either the message `OK` or with `VERIFY ERROR`.

VERIFY is obsolete in BASIC 65. It is only here for backwards compatibility. It is recommended to use **DVERIFY** and **BVERIFY** instead.

Examples: Using **VERIFY**

```
VERIFY "ADVENTURE"
VERIFY "ZORK-I",9
VERIFY "1:DUNGEON",10
```

VIEWPORT

Format: **VIEWPORT CLR**
VIEWPORT DEF x**,** y**,** width**,** height

Usage: Bitmap graphics: manages the viewport of a screen.

VIEWPORT DEF defines a clipping region with the origin (upper left position) set to **x, y** and the **width** and **height**. All following graphics commands are limited to the **VIEWPORT** region.

VIEWPORT CLR fills the clipping region with the colour of the drawing pen.

Remarks: The clipping region can be reset to full screen by the command `VIEWPORT DEF 0,0,WIDTH,HEIGHT` using the same values for WIDHTH and HEIGHT as in the SCREEN command.

Example: Using **VIEWPORT**

```
10 SCREEN 320,200,2
20 VIEWPORT DEF 20,30,100,120 :REM REGION 20->119, 30->149
30 PEN 1                      :REM SELECT COLOUR 1
40 VIEWPORT CLR               :REM FILL REGION WITH COLOUR OF PEN
50 GETKEY A$                  :REM WAIT FOR KEYPRESS
60 SCREEN CLOSE
```

VOL

Format: **VOL** right, left

Usage: Sets the volume for sound output with **SOUND** or **PLAY**.

right is the volume for SIDs 1 and 2, and **left** is the volume for SIDs 3 and 4. The value ranges from 0 (off) to 15 (loudest).

Remarks: The terms "right" and "left" refer to the default pan settings for the MEGA65 SID chips in the audio mixer. The actual volume and pan position for each pair of SIDs depends on the audio mixer settings. You can adjust the audio settings in the Freezer.

Example: Using **VOL**

```
10 TEMPO 22
20 FOR V = 2 TO 12 STEP 2
30 VOL V,16-V
40 PLAY "T0M3O4QGAGFED","T2O4M5P0H.DP5GB","T5O3IGAGAGAABABAB","G"
50 IF RPLAY(1) THEN GOTO 50
60 NEXT V
70 PLAY "T0O5QCO4GEH.C","T2O5IEFEDEDCEGO6P9CP0R","T5O3ICDCDEFEDCO4C","C"
```

VSYNC

Format: **VSYNC** raster line

Usage: Waits until the selected raster line is active.

raster line (0 - 311) for PAL, (0 - 262) for NTSC mode.

This pauses execution of the BASIC program until the screen update reaches the given vertical pixel coordinate. This is a very brief pause: the screen updates 50 times per second in PAL mode, and 60 times per second in NTSC mode. This is useful to change graphics parameters at specific points in the screen update, and to synchronize BASIC program logic with the screen refresh rate.

Example: Using **VSYNC**

```
10 IF FRE(-1)<920364 THEN PRINT"UPDATE ROM":END
20 BORDER 3     :REM CHANGE BORDER COLOUR TO CYAN
30 VSYNC 100    :REM WAIT UNTIL RASTER LINE 100
40 BORDER 7     :REM CHANGE BORDER COLOUR TO YELLOW
50 VSYNC 260    :REM WAIT UNTIL RASTER LINE 260
60 GOTO 20      :REM LOOP
```

WAIT

Format: **WAIT** address, andmask [, xormask]

Usage: Pauses the BASIC program until a requested bit pattern is read from the given address.

address the address at the current memory bank, which is read.

andmask AND mask applied.

xormask XOR mask applied.

WAIT reads the byte value from **address** and applies the masks: **result = PEEK(address) AND andmask XOR xormask**.

The pause ends if the result is non-zero, otherwise reading is repeated. This may hang the computer indefinitely if the condition is never met.

Remarks: **WAIT** is typically used to examine hardware registers or system variables and wait for an event, e.g. joystick event, mouse event, keyboard press or a specific raster line is about to be drawn to the screen.

Example: Using **WAIT**

```
10 BANK 128
20 WAIT 211,1            :REM WAIT FOR SHIFT KEY BEING PRESSED
```

WHILE

Format: **DO** ... **LOOP**
DO [<**UNTIL** | **WHILE**> logical expression]
. . . statements [**EXIT**]
LOOP [<**UNTIL** | **WHILE**> logical expression]

Usage: **DO** and **LOOP** define the start of a BASIC loop. Using **DO** and **LOOP** alone without any modifiers creates an infinite loop, which can only be exited by the **EXIT** statement. The loop can be controlled by adding **UNTIL** or **WHILE** after the **DO** or **LOOP**.

Remarks: **DO** loops may be nested. An **EXIT** statement exits the current loop only.

Examples: Using **DO** and **LOOP**

```
10 PW$="":DO
20 GET A$:PW$=PW$+A$
30 LOOP UNTIL LEN(PW$)>7 OR A$=CHR$(13)

10 DO : REM WAIT FOR USER DECISION
20 GET A$
30 LOOP UNTIL A$="Y" OR A$="N" OR A$="y" OR A$="n"

10 DO WHILE ABS(EPS) > 0.001
20 GOSUB 2000 : REM ITERATION SUBROUTINE
30 LOOP

10 I%=0 : REM INTEGER LOOP 1-100
20 DO I%=I%+1
30 LOOP WHILE I% < 101
```

WINDOW

Format: **WINDOW** left, top, right, bottom [, clear]

Usage: Sets the text screen window.

left left column

top top row

right right column

bottom bottom row

clear clear text window flag

By default, text updates occur on the entire available text screen. **WINDOW** narrows the update region to a rectangle of the available screen space.

Remarks: The row values range from 0 to 24. The column values range from 0 to either 39 or 79. This depends on the screen mode.

There can be only one window on the screen. Pressing CLR HOME twice or **PRINT**ing **CHR$(19)CHR$(19)** will reset the window to the default (full screen).

Example: Using **WINDOW**

```
10 WINDOW 0,1,79,24      :REM SCREEN WITHOUT TOP ROW
20 WINDOW 0,0,79,24,1    :REM FULL SCREEN WINDOW CLEARED
30 WINDOW 0,12,79,24     :REM LOWER HALF OF SCREEN
40 WINDOW 20,5,59,15     :REM SMALL CENTRED WINDOW
```

WPEEK

Format: **WPEEK(**address**)**

Returns: The 16-bit word value stored in memory at **address** (low byte) and **address** + 1 (high byte), as an unsigned 16-bit number.

If the address is in the range of $0000 to $FFFF (0 – 65535), the memory bank set by **BANK** is used.

Addresses greater than or equal to $10000 (decimal 65536) are assumed to be flat memory addresses and used as such, ignoring the **BANK** setting.

Remarks: Banks 0 – 127 give access to RAM or ROM banks. Banks greater than 127 are used to access I/O, and the underlying system hardware such as the VIC, SID, FDC, etc.

Example: Using **WPEEK**

```
20 UA = WPEEK($02F8)   :REM USR JUMP TARGET
50 PRINT "USR FUNCTION CALL ADDRESS";UA
```

WPOKE

Format: **WPOKE** address**,** word [**,** word ...]

Returns: Writes one or more 16-bit words into memory or memory mapped I/O, starting at **address**.

If the address is in the range of $0000 to $FFFF (0 – 65535), the memory bank set by **BANK** is used.

Addresses greater than or equal to $10000 (decimal 65536) are assumed to be flat memory addresses and used as such, ignoring the **BANK** setting.

word a value from 0 – 65535. The first word is stored at address (low byte) and address+1 (high byte). The second word is stored at address+2 (low byte) and address+3 (high byte), etc. If a value is larger than 65535, only the lower two bytes are used.

Remarks: The address is increased by two for each data word, so a memory range can be written to with a single **WPOKE**.

Banks greater than 127 are used to access I/O, and the underlying system hardware such as the VIC, SID, FDC, etc.

Example: Using **WPOKE**

```
10 BANK 128              :REM SELECT SYSTEM BANK
20 WPOKE $02F8,$1800     :REM SET USR VECTOR TO $1800
```

XOR

Format: operand **XOR** operand

Usage: Performs a bit-wise logical Exclusive OR operation on two 16-bit values.

Integer operands are used as they are. Real operands are converted to a signed 16-bit integer (losing precision). Logical operands are converted to 16-bit integer using $FFFF, (decimal -1) for TRUE, and $0000 (decimal 0) for FALSE.

Expression	Result
0 XOR 0	0
0 XOR 1	1
1 XOR 0	1
1 XOR 1	0

Remarks: The result is of type integer. If the result is used in a logical context, the value of 0 is regarded as FALSE, and all other non-zero values are regarded as TRUE.

Example: Using **XOR**

```
FOR I = 0 TO 8: PRINT I XOR 5;: NEXT I
 5  4  7  6  1  0  3  2  13
```

APPENDIX B

PETSCII Codes

- PETSCII Codes and CHR$

PETSCII CODES AND CHR$

In BASIC, `PRINT CHR$(X)` can be used to print a character from a PETSCII code. Below is the full table of PETSCII codes you can print by index. For example, while in the default uppercase/graphics mode, by using index 65 from the table below as: `PRINT CHR$(65)` you will print the letter `A`. You can read more about **CHR$** on page 114.

You can also do the reverse with the ASC statement. For example: `PRINT ASC("A")` will output `65`, which matches the code in the table.

NOTE: Function key (F1-F14 + HELP) values in this table are not intended to be printed via `CHR$()`, but rather to allow function-key input to be assessed in BASIC programs via the GET / GETKEY commands.

0
1 ALTERNATE PALETTE
2 UNDERLINE ON
3
4 DEFAULT PALETTE
5 WHITE
6
7 BELL
8
9 TAB
10 LINEFEED
11 DISABLE SHIFT
12 ENABLE SHIFT
13 RETURN
14 LOWER CASE
15 BLINK/FLASH ON
16 F9
17 ↓
18 RVS ON
19 CLR HOME
20 INST DEL
21 F10 / BACK WORD
22 F11
23 F12 / NEXT WORD
24 SET/CLEAR TAB
25 F13
26 F14 / BACK TAB
27 ESCAPE
28 RED
29 →
30 GREEN
31 BLUE
32 SPACE
33 !
34 "
35 #
36 $
37 %
38 &
39 '
40 (
41)
42 *
43 +
44 ,
45 -
46 .
47 /
48 0
49 1
50 2
51 3
52 4
53 5
54 6
55 7
56 8
57 9
58 :
59 ;
60 <
61 =
62 >
63 ?
64 @
65 A
66 B
67 C
68 D
69 E
70 F
71 G
72 H
73 I
74 J
75 K
76 L
77 M
78 N
79 O
80 P
81 Q
82 R
83 S
84 T
85 U
86 V

87 W
88 X
89 Y
90 Z
91 [
92 £
93]
94 ↑
95 ←
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126 π
127
128
129 ORANGE
130 UNDERLINE OFF
131 SHIFT RUN STOP
132 HELP
133 F1
134 F3
135 F5
136 F7
137 F2
138 F4
139 F6
140 F8
141 SHIFT RETURN
142 UPPERCASE
143 BLINK/FLASH OFF
144 BLACK
145 ↑
146 RVS OFF
147 SHIFT CLR HOME
148 SHIFT INST DEL
149 BROWN
150 LT. RED (PINK)
151 DK. GREY
152 GREY
153 LT. GREEN
154 LT. BLUE
155 LT. GREY
156 PURPLE
157 ←
158 YELLOW
159 CYAN
160 SPACE
161
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Note 1: Codes from 192 to 223 are equal to 96 to 127. Codes from 224 to 254 are equal to 160 to 190, and code 255 is equal to 126.

Note 2: While using lowercase/uppercase mode (by pressing + SHIFT), be aware that:

- The uppercase letters in region 65-90 of the above table are replaced with lowercase letters.
- The graphical characters in region 97-122 of the above table are replaced with uppercase letters.
- PETSCII's lowercase (65-90) and uppercase (97-122) letters are in ASCII's uppercase (65-90) and lowercase (97-122) letter regions.

APPENDIX C

Screen Editor Keys

- Screen Editor Keys
- Control codes
- Shifted codes
- Escape Sequences

SCREEN EDITOR KEYS

The following key combinations perform actions in the MEGA65 screen editor.

In some cases, a program can print the equivalent PETSCII codes to perform the same actions. For example, CTRL + G, which plays a bell sound, can be printed by a program as `CHR$(7)`. To print an ESC sequence, use `CHR$(27)` to represent the ESC key, followed by the next key in the sequence.

CONTROL CODES

Keyboard Control	Function
Colours	
CTRL + 1 to 8	Choose from the first range of colours. See appendix E on page 281 for the list of colours in the system palette.
M + 1 to 8	Choose from the second range of colours.
CTRL + E	Restores the colour of the cursor back to the default (white).
CTRL + D	Switches the VIC-IV to colour range 0-15 (default colours). These colours can be accessed with CTRL and keys 1 to 8 (for the first 8 colours), or M and keys 1 to 8 (for the remaining 8 colours).
CTRL + A	Switches the VIC-IV to colour range 16-31 (alternate/rainbow colours). These colours can be accessed with CTRL and keys 1 to 8 (for the first 8 colours), or M and keys 1 to 8 (for the remaining 8 colours).
Tabs	

Keyboard Control	Function
CTRL + Z	Tabs the cursor to the left. If there are no tab positions remaining, the cursor will remain at the start of the line.
CTRL + I	Tabs the cursor to the right. If there are no tab positions remaining, the cursor will remain at the end of the line.
CTRL + X	Sets or clears the current screen column as a tab position. Use CTRL + Z and I to jump back and forth to all positions set with X.
Movement	
CTRL + Q	Moves the cursor down one line at a time. Equivalent to ↓.
CTRL + J	Moves the cursor down a position. If you are on a long line of BASIC code that has extended to two lines, then the cursor will move down two rows to be on the next line.
CTRL +]	Equivalent to →.
CTRL + T	Backspace the character immediately to the left and to shift all rightmost characters one position to the left. This is equivalent to INST DEL.
CTRL + M	Performs a carriage return, equivalent to RETURN.
Word movement	
CTRL + U	Moves the cursor backward to the start of the previous word. If there is no previous word on the current line, it moves to the first column of the current line, then to the previous line, until a line with a word is encountered.

Keyboard Control	Function
CTRL + W	Advances the cursor forward to the start of the next word. If there is no next word on the current line, it moves to the first column of the next line, until a line with a word is encountered.
Scrolling	
CTRL + P	Scroll BASIC listing down one line. Equivalent to F9.
CTRL + V	Scroll BASIC listing up one line. Equivalent to F11.
CTRL + S	Equivalent to NO SCROLL.
Formatting	
CTRL + B	Enables underline text mode. You can disable underline mode by pressing ESC, then O.
CTRL + O	Enables flashing text mode. You can disable flashing mode by pressing ESC, then O.
Casing	
CTRL + N	Changes the text case mode from uppercase to lowercase.
CTRL + K	Locks the uppercase/lowercase mode switch usually performed with M + SHIFT.
CTRL + L	Enables the uppercase/lowercase mode switch that is performed with the M + SHIFT.
Miscellaneous	
CTRL + G	Produces a bell tone.
CTRL + [	Equivalent to pressing ESC.
CTRL + *	Enters the Matrix Mode Debugger.

SHIFTED CODES

Keyboard Control	Function
SHIFT + INST DEL	Insert a character at the current cursor position and move all characters to the right by one position.
SHIFT + HOME	Clear home, clear the entire screen, and move the cursor to the home position.

ESCAPE SEQUENCES

To perform an Escape Sequence, briefly press and release ESC, then press one of the following keys to perform the sequence.

Key	Sequence
Editor behaviour	
ESC X	Clears the screen and toggles between 40 × 25 and 80 × 25 text modes.
ESC 4	Clears the screen and switches to 40 × 25 text mode.
ESC 8	Clears the screen and switches to 80 × 25 text mode.
ESC 5	Switches to 80 × 50 text mode.
Note that some programs expect to be started in 80 × 25 mode, and may not behave correctly when started in 80 × 50 mode.	

Key	Sequence
ESC @	Clears a region of the screen, starting from the current cursor position, to the end of the screen.
ESC O	Cancels the quote, reverse, underline, and flash modes.
Scrolling	
ESC V	Scrolls the entire screen up one line.
ESC W	Scrolls the entire screen down one line.
ESC L	Enables scrolling when ↓ is pressed at the bottom of the screen.
ESC M	Disables scrolling. When pressing ↓ at the bottom of the screen, the cursor will move to the top of the screen. However, when pressing ↑ at the top of the screen, the cursor will remain on the first line.
ESC N	Enables "line pushing:" typing or printing in the rightmost column pushes subsequent lines down by one.
ESC R	Disables "line pushing:" typing or printing in the rightmost column moves the cursor to the beginning of the next line, but does not push any lines. Disable both line pushing (ESC R) and scrolling (ESC M) to allow **PRINT**ing in the rightmost column without disturbing the rest of the display.
Insertion and deletion	
ESC I	Inserts an empty line at the current cursor position and moves all subsequent lines down one position.

Key	Sequence
ESC D	Deletes the current line and moves lines below the cursor up one position.
ESC P	Erases all characters from the cursor to the start of the current line.
ESC Q	Erases all characters from the cursor to the end of the current line.
Movement	
ESC J	Moves the cursor to the start of the current line.
ESC K	Moves the cursor to the last non-whitespace character on the current line.
ESC ↑	Saves the current cursor position. Use ESC ← (next to 1) to move it back to the saved position. Note that the ↑ used here is next to RESTORE.
ESC ←	Restores the cursor position to the position stored via a prior a press of the ESC ↑ (next to RESTORE) key sequence. Note that the ← used here is next to 1.
ESC HOME	Restores the cursor position to the position stored via a prior a press of HOME.
Windowing	
ESC T	Sets the top-left corner of the windowed area. All typed characters and screen activity will be restricted to the area. Also see ESC B. Windowed mode can be disabled by pressing CLR HOME twice.

Key	Sequence
ESC B	Sets the bottom right corner of the windowed area. All typed characters and screen activity will be restricted to the area. Also see ESC T. Windowed mode can be disabled by pressing CLR HOME twice.
Cursor behaviour	
ESC A	Enables auto-insert mode. Any keys pressed will be inserted at the current cursor position, shifting all characters on the current line after the cursor to the right by one position.
ESC C	Disables auto-insert mode, reverting back to overwrite mode.
ESC E	Sets the cursor to non-flashing mode.
ESC F	Sets the cursor to regular flashing mode.
Bell behaviour	
ESC G	Enables the bell which can be sounded using CTRL and G.
ESC H	Disable the bell so that pressing CTRL and G will have no effect.
Colours	
ESC U	Switches the VIC-IV to colour range 0-15 (default colours). These colours can be accessed with CTRL and keys 1 to 8 (for the first 8 colours), or MEGA and keys 1 to 8 (for the remaining colours).

Key	Sequence
ESC S	Switches the VIC-IV to colour range 16-31 (alternate/rainbow colours). These colours can be accessed with CTRL and keys 1 to 8 (for the first 8 colours), or MEGA and keys 1 to 8 (for the remaining colours).
Tabs	
ESC Y	Set the default tab stops (every 8 spaces) for the entire screen.
ESC Z	Clears all tab stops. Any tabbing with CTRL and I will move the cursor to the end of the line.

APPENDIX D

Screen Codes

- Screen Codes

SCREEN CODES

A text character is represented in screen memory by a screen code. There are 256 possible screen codes, each referring to an image in the current character set.

A complete character set contains two groups of 256 images, one for the uppercase mode and one for the lowercase mode, for a total of 512 images. Only one mode can be displayed at a time. The built-in character sets use the first 128 characters of each group for normal characters and the next 128 for reversed versions of the same characters.

In BASIC, the **T@&()** special array provides access to the characters on the screen using column and row indexes. The values in this special array are screen codes. The **FONT** command changes between the built-in character sets. The **CHARDEF** command changes the image associated with a screen code.

Note: Screen codes are different to PETSCII codes. PETSCII codes are used to store, transmit, and receive textual data, and control the way strings are printed to the screen. When a PETSCII character is printed to the screen, the corresponding screen code is written to screen memory. For a list of PETSCII codes, see appendix B on page 261.

The following table lists the screen codes. When a code produces a different character based on the mode, the character is listed as "uppercase / lowercase."

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

56	8
57	9
58	:
59	;
60	<
61	=
62	>
63	?
64	
65	/ A
66	/ B
67	/ C
68	/ D
69	/ E
70	/ F
71	/ G
72	/ H
73	/ I
74	/ J
75	/ K
76	/ L
77	/ M
78	/ N
79	/ O
80	/ P
81	/ Q
82	/ R
83	/ S
84	/ T
85	/ U
86	/ V
87	/ W
88	/ X
89	/ Y
90	/ Z
91	
92	
93	
94	π /
95	/
96	space
97	
98	
99	
100	
101	
102	
103	
104	
105	/
106	
107	
108	
109	
110	
111	
112	
113	
114	
115	
116	
117	
118	
119	
120	
121	
122	/
123	
124	
125	
126	
127	

Note: In the built-in character sets, codes 128-255 are reversed versions of 0-127.

APPENDIX E

System Palette

- System Palette

SYSTEM PALETTE

The following table describes the system colour palette as it is defined by default.

Colour palette indexes are used as values in the **C@&()** special array, and as arguments for BASIC commands such as **BACKGROUND**, **BORDER**, **COLOR**, **FOREGROUND**, **HIGHLIGHT**, **PEN**, and **SCREEN CLR**.

Index	Red	Green	Blue	Colour
0	0	0	0	Black
1	15	15	15	White
2	15	0	0	Red
3	0	15	15	Cyan
4	15	0	15	Purple
5	0	15	0	Green
6	0	0	15	Blue
7	15	15	0	Yellow
8	15	6	0	Orange
9	10	4	0	Brown
10	15	7	7	Light Red (Pink)
11	5	5	5	Dark Grey
12	8	8	8	Medium Grey
13	9	15	9	Light Green
14	9	9	15	Light Blue
15	11	11	11	Light Grey
16	14	0	0	Guru Meditation
17	15	5	0	Rambutan
18	15	11	0	Carrot
19	14	14	0	Lemon Tart
20	7	15	0	Pandan
21	6	14	6	Seasick Green
22	0	14	3	Soylent Green
23	0	15	9	Slimer Green
24	0	13	13	The Other Cyan
25	0	9	15	Sea Sky
26	0	3	15	Smurf Blue
27	0	0	14	Screen of Death
28	7	0	15	Plum Sauce
29	12	0	15	Sour Grape
30	15	0	11	Bubblegum
31	15	3	6	Hot Tamales

APPENDIX F

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The MEGA65 would not have been possible to create without the generous support of many organisations and individuals.

We are still compiling these lists, so apologies if we haven't included you yet. If you know anyone we have left out, please let us know, so that we can recognise the contribution of everyone who has made the MEGA65 possible, and into the great retro-computing project that it has become.

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[2] Reserved variable
[3] Also boolean operators
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Editors:

Assoc. Prof. Paul Gardner-Stephen
Dr. Edilbert Kirk

Authors:

Assoc. Prof. Paul Gardner-Stephen
Dr. Edilbert Kirk
Detlef Hastik
Gürçe Işıkyıldız
Stephan Kleinert
Maurice van Gils
Wayne Johnson
Daren Klamer
Jim Nicholls
Oliver Graf
Dan Sanderson

and many other contributors

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