

Frodo

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Chapter 1

Frodo

1.1 Frodo Manual

Frodo
Version 1.0

A Commodore 64 emulator
for Commodore-Amiga computers

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Freely distributable

Overview	Why another C64 emulator?
Installation	How to install Frodo
Start/quit	There and back again
Settings	You only have to configure...
Keyboard layout	Where the hell is the "any" key?
File access	A 64 with hard disk
Printers	Using C64 printers
The SID card	Where is the sound?
The IEC cable	How to connect a 1541 to the Amiga
Sample programs	The included demo programs
Technical info	Revealing the secrets
The source	Use the source, Luke.
Program messages	Translation of messages
Copyright	Legal mush
Bug reports	Got some problems?
Credits	The author wishes to thank...
The author	Programmer's address
History	Revision history of Frodo

1.2 Overview

"Those days, the Third Age of Middle-earth,
are now long past, and the shape of all lands
has been changed."

Frodo is a multitasking C64 emulator for the Commodore Amiga and the world's first C64 emulator not bearing a "64" in its name. :-)

Frodo was especially developed to reproduce the graphics of games and demos better than the existing emulators for the Amiga. Therefore Frodo needs much more computing power than other emulators. Even using a 25MHz 68040 gives only slightly more than half of the 64's original speed. But on the other hand, Frodo can display raster effects correctly that only result in a flickering mess under "A64".

An Amiga with (at least) OS2.1, a 68020 processor and 1MB RAM is required. Frodo can use the built-in Amiga graphic capabilities as well as access EGS graphics cards and the "Picasso" directly to improve performance.

The program is not a 100% emulation (is there such?), the main missing things are:

- Only line-by-line raster effects possible
- No sprite-graphics priorities
- No sprite-background collisions
- Sound only over SID card
- Neither Amiga printers nor RS232 usable

But the next version is coming real soon now... :-)

1.3 Installation

The archive contains the following files:

README	- Short description
Frodo	- Main program
Frodo.info	- Its icon
Frodo.guide	- The german version of this manual
Frodo.guide.info	- Its icon
FrodoEng.guide	- This manual
FrodoEng.guide.info	- Its icon
Frodo Prefs	- Preferences file
Frodo Prefs.info	- Its icon
Basic ROM.info	- Icon for Basic ROM
Kernal ROM.info	- Icon for Kernal ROM
Char ROM.info	- Icon for Character ROM
64prgs/#?	- Some sample programs
src/#?	- Source

All you have to do is to unpack the archive somewhere onto your hard disk. Frodo doesn't need any assigns, but copies of the original C64 ROMs are required. For legal reasons these are not included in the archive and you have to get them elsewhere.

Frodo looks for three ROM files named "Basic ROM", "Kernal ROM" and "Char ROM" in the same directory Frodo is in. If you already have

ROM files for "A64 V2.0" (not the *.data files, these are not the real ROMs), you can simply rename them and use them with Frodo. Otherwise, they can be read from a real C64 by means of the following program:

```
10 OPEN 1,8,2,"BASIC ROM,S,W"
20 FOR X=40960 TO 49151:PRINT#1,CHR$(PEEK(X));:NEXT
30 CLOSE 1
40 OPEN 1,8,2,"KERNAL ROM,S,W"
50 FOR X=57344 TO 65535:PRINT#1,CHR$(PEEK(X));:NEXT
60 CLOSE 1
70 POKE 56334,0:POKE 1,51
80 FOR X=16384 TO 20479:POKE X,PEEK(X+36864):NEXT
90 POKE 1,55:POKE 56334,1
100 OPEN 1,8,2,"CHAR ROM,S,W"
110 FOR X=16384 TO 20479:PRINT#1,CHR$(PEEK(X));:NEXT
120 CLOSE 1
```

Unfortunately, Frodo has no function to get these files saved on a C64 disk to the Amiga, but you can transfer them via a null-modem cable or using A64 or any of the 1541-to-Amiga transfer utilities. (Frodo can indeed access C64 disk drives, but to start Frodo you must already have the ROMs %-).

1.4 Start/quit

After a double click on the icon, the window for the emulation Settings appears.

The actual emulation is started by a click on "OK". Then, at first a black screen should appear followed by the C64 startup message after some seconds. Clicking the right mouse button will quit the emulator at any time.

1.5 Settings

The settings window appears directly after starting Frodo, or by pressing F9 in the running emulation. Sorry, the names of the gadgets are in german, but I'll give you the translations in brackets.

"Zyklen pro Zeile (CPU)" [Cycles per line (CPU)] and "Zyklen pro Bad Line (CPU)" [Cycles per bad line (CPU)] control the relation of graphics speed and processor speed. The higher the values, the faster the emulated CPU, but the slower the graphics refresh speed. If a program is showing flickering lines or graphical flaws you should try to slightly alter both values.

With "Zyklen pro Zeile (CIA)" [Cycles per line (CIA)] you can control the speed of the CIA timers. Entering a higher value increases the frequency of cursor blinking and key repeat. Some programs don't run correctly with the default value (e.g. "Ballblazer" which needs a value of 65).

The settings for the three "Cycles" coming closest to an original PAL C64 are (63,23,63).

"Joystick an Port 1/2" [Joystick on Port 1/2] relates to the Amiga ports. Normally, you will want to have port 1 switched off if you have your mouse connected there. With "Joysticks vertauschen" [Swap joysticks] you can swap the assignment of the Amiga ports to the C64 ports without having to plug out and in your joysticks. E.g. if a C64 game is using a joystick on port 1 you can simply activate "Joysticks vertauschen" and use a joystick in port 2 to play the game.

The keyboard layout normally matches that of a german keyboard (Y and Z swapped). With "Amerik. Tastatur" [American keyboard] you can prevent the swapping (preferable, if you are not using a german keyboard).

With "SID-Karte benutzen" [Use SID card] you specify if the sound emulation should be done over the SID card or if there should not be any sound. If you don't have a SID card, you should leave this gadget switched off to prevent illegal memory accesses.

The setting "Bildschirm-Typ" [Screen type] determines the way Frodo controls the graphics. The choices are "Amiga" (for using the built-in Amiga graphics), "EGS" (for EGS graphics cards) and "Picasso" (for the Picasso graphics card). After choosing the screen type, you have to select an appropriate resolution using "Bildschirmmodus" [Screen mode]. The display on graphics cards is faster than the Amiga graphics. These settings can not be altered in the middle of the running emulation.

Next to "Laufwerk 8" [Drive 8] to "Laufwerk 11" [Drive 11] you give the paths of directories (relative to the directory Frodo is in) that are used for the simulation of disk drives 8, 9, 10 and 11 (see file access). Clicking on the symbols to the right of the string gadgets will open a requester to select the directory more user friendly.

The four checkmark gadgets under "IEC" control whether the belonging disk drive is to be accessed over the IEC cable as real C64 devices. If you have, for example, a real 1541 with drive number 8 connected to your Amiga, you have to activate the "IEC" checkmark for drive 8 to use the 1541 (instead of the simulated one).

When the symbol "IEC für andere Geräte verwenden" [Use IEC for other devices] is active, Frodo uses the IEC cable also for device numbers 4 to 7 and 12 to 15. So, if you have connected a C64 printer with device number 4, you should click on this gadget to use the printer. If this gadget is not activated, all device numbers except 8 to 11 give a "device not present error".

By clicking "Sichern" [Save] the settings are saved on disk to be reloaded next time you start Frodo. "OK" will start the actual emulation (resp. return to it) and "Abbrechen" [Cancel] will discard your changes to the settings and quit Frodo (resp. discard the changes and return to the emulation).

1.6 Keyboard layout

The keyboard layout closely resembles that of a C64, but the "Y" and "Z" keys are normally swapped (german keyboard layout). This can be prevented by clicking on "Amerik. Tastatur" in the settings window.

The individual rows of the keyboard are mapped as follows:

```
<- 1 2 3 4 5 6 7 8 9 0 + - £
    Q W E R T Z U I O P @ *
    A S D F G H J K L : ; =
    ^ Y X C V B N M , . /
```

In addition, the following key are used:

```
ESC   - RUN/STOP
<-    - INS/DEL
Del    - CLR/HOME
Help   - RESTORE
Amiga  - C=
F1-F8  - F1-F8
F9     - Opens the settings window
F10    - Resets the C64
```

So the famous key combination RUN/STOP-RESTORE corresponds to ESC-Help on the Amiga keyboard. But you don't have to thrash the Help key the same way as the RESTORE key on the original C64. :-)

The cursor (arrow) keys can be used as on the Amiga. I.e. "cursor up" corresponds to "Shift-cursor down" on the C64. The same applies to the function keys F2, F4, F6 and F8.

1.7 File access

Frodo can simulate 1541 drives with the drive numbers 8, 9, 10 and 11 in Amiga directories as well as access real C64 drives by means of an IEC cable. So you can store your C64 programs on your Amiga's hard disk and LOAD and SAVE them as usual from Frodo. The paths to the directories of the simulated drives are given in the settings window under "Laufwerk 8" to "Laufwerk 11".

You can even load the directory with LOAD"\$",8. All files marked as executable are displayed as "PRG", all the others as "SEQ". The file type "DIR" marks an Amiga subdirectory. To get into it you have to open the settings window and change the path for the drive, as the operating system of the C64 doesn't know about subdirectories. It is possible to use a "/" in the C64 file name to access these subdirectories, though (e.g. LOAD"GAMES/ELITE",8).

The specification of file type and access mode in file names is not supported (e.g. OPEN1,8,2,"TESTFILE,S,W" doesn't work as expected).

For connecting real C64 drives you need a special cable to hook them to your Amiga. Then you have to activate the symbol "IEC" for the

corresponding drive number in the settings, so Frodo will know that this drive number belongs to a device on the IEC cable. Drives connected this way can be used like from the C64, but speed loaders are most probably not working.

1.8 Printers

Frodo can't use Amiga printers, but you can connect a C64 IEC printer using the IEC cable that is accessed as usual under the C64. You have to activate the gadget "IEC für andere Geräte verwenden" in the settings window to use the printer.

1.9 The SID card

Frodo has no sound emulation over the Amiga's hardware. Instead, it expects a real C64 sound chip (SID) on a slot card in the Amiga. This card (a unique example for now) maps the SID into the address range starting at \$a00001 (odd addresses).

If you are interested in rebuilding the card, you can ask me for the schematics. The design isn't very good, but the card does its job.

1.10 The IEC cable

"This is Ohm of Borg.
Resistance is voltage divided by electric current." :-)

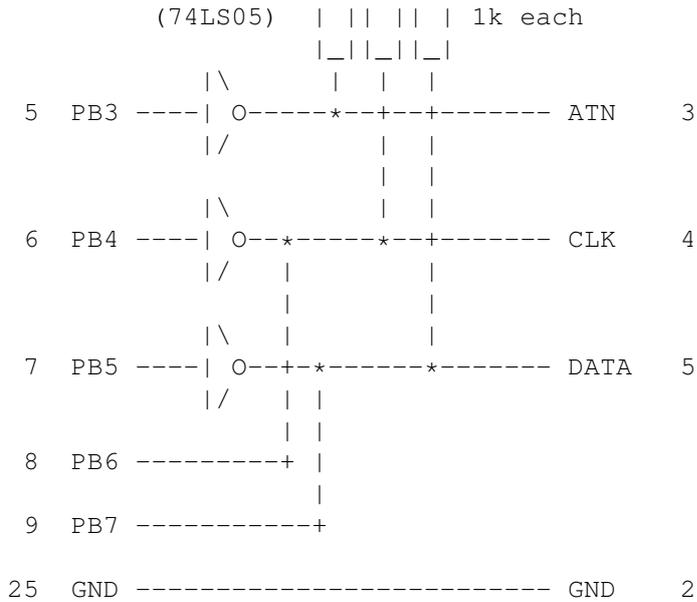
The best way to transfer your old C64 software to the Amiga is to connect a real C64 disk drive. To do this, you need a special cable with a small circuit that, together with Frodo's software, will expand your Amiga by the so-called "IEC" bus system that is used on the C64 for connecting disk drives and printers.

If you already have such a cable for the "A64" you most probably can also use it with Frodo (untested). The cable described in the german "Amiga Magazin" issue 8/88, p.36 is not usable with Frodo as it has inverted output lines.

Building an IEC cable is fairly simple, it connects the parallel port of the Amiga with the round 6-pin connector on the C64 devices.

Parallel port	IEC connector
Amiga	1541
DSUB, 25-pin	DIN, 6-pin

Pin	Name		Name	Pin
14	+5V	-----*---*---+		
		~ ~ ~		
	7406			



The 7406 (a 74LS05 will do as well) must be connected to +5V and GND of course. The trained technician will notice that this is the same circuit found inside the real C64.

[Important note: If you plan to build and connect such a cable, please remember that you do it on your own risk. I will not take any responsibility if there is blue smoke coming out from the back of your computer!]

1.11 Sample programs

The directory "64prgs" contains some little sample programs to show the capabilities (and weaknesses) of Frodo. They are all loaded with LOAD"<name>",8 and started with SYS49152. To do so, you have to type '64prgs' in the settings for "Laufwerk 8" so Frodo will find the programs.

If you like, you can try these programs on other emulators or on a real C64.

A short description of each program:

```

3fff      : Opens the top and bottom border and displays swinging
           letters ("Zyklen pro Zeile (CPU)" should be set to 60
           for this one)
colorbars: Flickering colors
dycp      : Scrolling with different Y character position
fld        : Demonstrates the FLD effect (flexible line distance)
stretch    : One thing Frodo is not (yet) able to emulate: variably
           expanded sprites
tech-tech: Horizontal scrolling with large amplitude (use joystick
           in port 2 to control)
text26     : Displays (nearly) 26 lines of text
monitor    : A simple machine language monitor

```

1.12 Technical info

"Wissen?" wiederholte Gandalf.

"Ich weiß vieles, was nur die Weisen wissen, Frodo."

[Does someone know the english original of this? LotR, (I, 2)]

In contrast to A64 that is biased towards the Amiga hardware, Frodo tries to exactly imitate C64 hardware features. Now the 64's hardware (esp. the graphics chip "VIC") has a rather simple design resulting in many of the internal processes coming to the "outside". So there are lots of "undocumented features" you can do effects with the designers never dared to dream about.

Frodo uses a line-by-line emulation, i.e. the function of the VIC and the processor (6510) are emulated for one raster line of the C64 screen at times. In practice, Frodo runs VIC and 6510 alternately for 63 simulated cycles each (corresponding to one raster line). At first, it emulates the processor for 63 cycles, then switches over to the VIC that paints one pixel row to the screen, then again 63 cycles processor, and so on...

Even though this is a heavy simplification of the processes in a real C64, it lets you perfectly emulate many graphical effects possible on the 64, e.g. FLD, FLI, DYCP, hyperscreen and many more. But this method has one big disadvantage: Changes made to VIC registers by the processor in the middle of a raster line will only take effect at the start of the next line. E.g. you can't change the border color in the middle of a line, the color change takes place in the next line. Therefore, very sophisticated techniques depending on the exact position of a register change can't be emulated. For instance, it is no problem to open the top and bottom border, but opening the left and right border is impossible (and therefore not implemented in the emulation).

The next step above line-by-line emulation would be to resolve VIC and 6510 into single cycles. The processes in the VIC and the 6510 for each cycle are quite well known, so there is no theoretical problem in the realization. The only real problem is speed. You would have to switch between VIC and 6510 after every cycle, instead of after 63 cycles as Frodo does in the moment. This would mean abandoning the register-based 6510 emulation, as the overhead for storing and retrieving the complete register set for every switch would be too great.

The present opcode dispatch model would have to be replaced by some kind of "cycle continuation pointer" pointing to the subroutine for the next cycle of the current opcode (or should the opcode dispatch table be extended by 8 entries for each opcode for the single cycles?). As a first estimation, the speed would go down by a factor of 4-10, so before the availability of faster Amigas there is no hope for cycle based emulation. Though you could emulate effects like AFLI and the VC and sprite counter confusions of the VIC precisely.

1.13 The source

For those confused by the numbers: A small description of all modules:

```
6510.asm      - The processor
6526.asm      - The CIAs (in/output, keyboard, timers)
6569.asm      - The VIC (graphics)
6581.asm      - The SID (sound)
1541.asm      - File access and IEC routines
c2p4.asm      - Chunky->planar conversion
FrodoPrefs.#? - GadToolsBox user interface of settings window
Frodo_rev.#?  - Version information
Main.asm      - The main module
Boopsi.o      - An object file from GadToolsBox to be linked in
```

The calls for assembling and linking are:

```
PhxAss Main.asm INCPATH Include: OPT !
PhxAss 6510.asm INCPATH Include: OPT !
PhxAss 6569.asm INCPATH Include: OPT !
PhxAss 6526.asm INCPATH Include: OPT !
PhxAss 6581.asm INCPATH Include: OPT !
PhxAss 1541.asm INCPATH Include: OPT !
PhxAss FrodoPrefs.s INCPATH Include: OPT !
PhxAss c2p4.asm INCPATH Include: OPT !
PhxLnk Lib:RXstartup.obj Main.o 6510.o 6569.o c2p4.o 6526.o 6581.o
      1541.o FrodoPrefs.o Boopsi.o Lib:small.lib TO Frodo
```

1.14 Translation of program messages

Requester texts:

"Wählen Sie einen Bildschirmmodus"
- Choose a screen mode

"Wählen Sie ein Verzeichnis"
- Choose a directory

"Frodo benötigt mindestens einen 68020 Prozessor."
- Frodo requires at least a 68020 processor

"Es steht nicht genügend Speicher zum Starten des Emulators
zur Verfügung."
- There is not enough memory to start the emulator

"Der C64-Bildschirm kann nicht eingerichtet werden."
- The C64 screen cannot be created

"EGS ist auf Ihrem Amiga nicht installiert.
Bitte wählen Sie 'Amiga' oder 'Picasso' als Bildschirmtyp."
- EGS is not installed on your Amiga. Please select 'Amiga'
or 'Picasso' for the screen type

"Die 'vilintuisup.library' ist auf Ihrem Amiga nicht installiert.
Bitte wählen Sie 'Amiga' oder 'EGS' als Bildschirmtyp."
- The 'vilintuisup.library' is not installed on your Amiga.

Please select 'Amiga' or 'Picasso' for the screen type

"Der gewählte Bildschirmmodus ist auf Ihrem Amiga nicht verfügbar."
- The selected screen mode is not available on your Amiga

"Der von Ihnen gewählte Bildschirmmodus hat eine zu geringe Auflösung.
Sie muß mindestens 384\$\\times\$288 betragen."
- The resolution of the selected screen mode is too small.
It must be greater than 384\$\\times\$288

"Die Datei 'xxx' fehlt oder ist beschädigt."
- The file 'xxx' is missing or damaged

"Der parallele Port ist zur Zeit von einem anderen Programm belegt.
Die Benutzung von IEC-Geräten ist daher nicht möglich."
- The parallel port is currently in use by another program.
So the use of IEC devices is not possible

"Frodo kann keinen freien CIA-Timer finden. Die Benutzung von
IEC-Geräten ist daher nicht möglich."
- Frodo is unable to find a free CIA timer. So the use of IEC devices
is not possible

"Unbekannter Opcode xx, PC yyyy"
- Unknown opcode xx, PC yyyy

"Sprung in den I/O-Bereich, PC yyyy"
- Jump to I/O space, PC yyyy

Requester gadgets:

"Beenden"
- Quit

"Macht nichts"
- Don't care

"Reset"
- Reset (guessed that? :-)

"Na und?"
- So what?

1.15 Copyright and distribution

The program "Frodo", this manual and the source code may be freely distributed as long as they remain unchanged (archiving and packing is allowed) and all files are included. You must not make any profit by selling Frodo, especially the price of a disk containing Frodo may not exceed US\$ 5,- (or equivalent amounts in other currencies). Please feel free to distribute Frodo over bulletin board systems and networks and as part of shareware/freeware CD-ROMs.

Anyone using this program agrees to incur the risk of using it for

himself. In no way can the author be held responsible for any damage directly or indirectly caused by the use or misuse of this manual and/or the program.

The rights on the source code remain at the author. It may not - not even in parts - used for commercial purposes without explicit written permission by the author. Permission to use it for non-commercial purposes is hereby granted as long as my copyright notice remains in the program. You are not allowed to use the source to create and distribute a modified version of Frodo.

The user interface of the program was designed with GadToolsBox
© Copyright 1991-1993 Jaba Development.

Parts of the program are © Copyright 1992-1993 Jaba Development.

1.16 Bug reports

If you find a bug or a misfeature in Frodo, or have an idea how to make some things better, then please drop me a note so I'll be able to improve Frodo in the future. My address can be found here.

I don't think the emulation can be made much faster without changing the concept but I'll be happy to find someone showing me how to do it.

1.17 Credits

The following persons deserve special thanks from me as they made a significant contribution to the development of Frodo.

- Frank Wille <phoenix@komet.guru.sub.de>, whose PhxAss was used for developing Frodo
- Jaba Development, whose GadToolsBox developed Frodo's user interface
- Peter McGavin <peterm@maths.grace.cri.nz>, who wrote the chunky-to-planar conversion
- Andreas Boose <a.boose@ldb.han.de> and Marko Mäkelä <marko.makela@hut.fi>, who provided me with precious information on the VIC and on the C64 in general
- Markus Winklbauer <sysop@ng-box.wwb.sub.de>, for the docs for the Picasso card
- J.R.R.Tolkien for the suggestion for the name of the emulator

1.18 The author

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cbauer@mzdmza.zdv.uni-mainz.de (More reliable but polled
less frequently)

Questions, criticism, suggestions and bug reports are always welcome. E-Mail is preferred.

Frodo is not a shareware program, but I won't reject any gifts. :-)

1.19 History

This emulator started as a player routine for C64 music (therefore the SID card) until I saw A64 V3.0 and was so disappointed of it that I began to write a "real" C64 emulator (around christmas 1994).

V0.4 05.Jan.1995

- First released version

V0.5 10.Jan.1995

- Starting Frodo on a 68000 correctly gave a requester but then the computer crashed. I told you this only works on 68020+ :-)
- Removed two enforcer hits in the memory configuration routine
- Frank Wille's email address corrected
- Sprite cycles are now calculated correctly
- Switching off a sprite in the middle of its display blanked it immediately. Now it is drawn completely.
- Graphics speed for EGS/Picasso improved by means of a line buffer (20% faster), other small optimizations to the graphics
- VIC interrupt flag is now clear on every write access to \$d019 (a hack for RMW commands doing two write accesses)
- CIA timers B are now capable of counting underflows of timer A (for "Ballblazer" :-)
- PLP and RTI clear the break flag
- Completely new 1541 emulation, 4 drives
- CPU cycle counter heavily optimized (again 25% gain in speed)

V1.0 25.Jan.1995

- PHP now sets the break flag on stack
 - HandleRESET erroneously set the I flag (don't trust a data sheet, even if it's from the manufacturer...)
 - A RESET will set the VIC bank to 0
 - All illegal opcodes implemented
 - New algorithm for the VIC's VC that is more close to the real VIC
 - The VBlank routines now jump back to Periodic6569 as there was a non-existent -1st line
 - TOD clocks implemented
 - ECM+BMM, ECM+MCM and ECM+BMM+MCM now correctly display a black screen
 - Access to SID card is now disable-able (!? :-)
 - Some bugs in 1541 emulation corrected
 - Use of IEC devices over an adapter cable is now possible
 - Selecting the directories for the 1541 emulation can now be done
-

- with a directory requester
 - Turning off the screen using bit 4 of \$D011 is working
 - Setting for "raster frequency" removed
 - Interrupt handling completely rewritten
 - Some internal optimizations
 - During a reset, the CBM80 signature is now only overwritten if it is present
 - Frodo now works on non-AGA machines
 - Sprite-sprite collisions implemented
 - Swapping of Y and Z keys is now a settings item
-