1541u-documentation Documentation

Release latest

# Contents

Quick guide to the Ultimate-II+

Thank you for purchasing the "Ultimate-II+" cartridge: The versatile storage solution for your Commodore 64 computer. Although the installation and use of the Ultimate-II+ are designed to be intuitive, this quick guide shows you the basic functions.

1.1 Installation

1. Take a USB stick, and use a PC or Mac to transfer your favorite floppy disk images (.D64 or .G64 files), tape archives (.T64 files), tape images (.TAP files), Amiga MOD files, SID music (.SID files), or separate programs (.PRG files) to this USB stick.

2. Insert the USB stick into one of the available USB slots on the Ultimate-II+.

3. Take the Ultimate-II+, and carefully slide it into the cartridge slot of your C=64. Connect the supplied serial cable between the serial port connector to the serial port of the computer. In case you want to use a configuration with a real drive, connect the computer to the drive first and then use the feed through of the drive to attach the Ultimate-II+ as the last device in the chain.

1.2 Ports and buttons
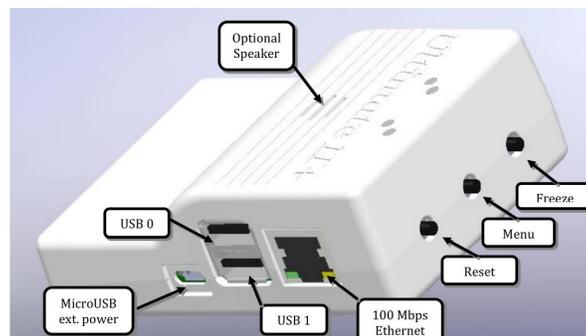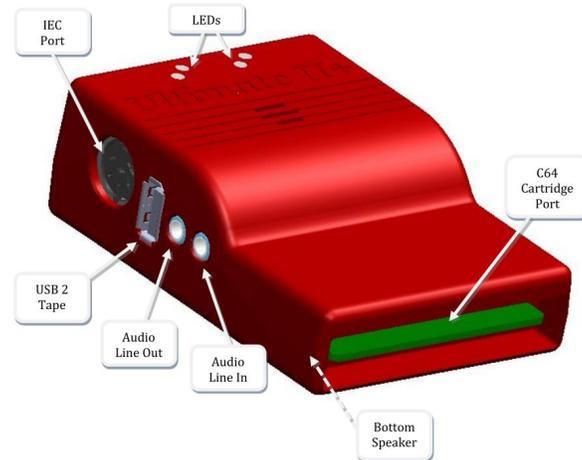
1.3 Concept of operation

The main feature of the Ultimate-II+ is a cycle accurate implementation of the Commodore 1541 Floppy Disk Drive. This part of the Ultimate-II+ cartridge thus acts exactly like a real drive. It is not any faster or any slower than a real floppy disk drive.

Just like a real 1541 disk drive, the Ultimate-II+ needs "floppy disks". On the Ultimate-II+, these floppy disks are *virtual*. These virtual disks exist in the form of a .D64 or .G64 file on a storage device, such as the supplied USB stick. When the user selects such a file, it is linked to the emulated drive. This process is called *'mounting'*. After mounting (which will take a few seconds to complete), the 1541 can access the image file as if it was a real floppy. All standard commands that you are familiar with while using a real CBM1541 then apply.

1.4 The Menu

The Ultimate-II+ provides a user friendly menu driven interface, which can be accessed by pressing the middle button on the back of the cartridge. Pressing this button will interrupt the currently running program on the C=64 and show the menu. Leaving the menu will resume the C=64 gracefully. The main two functions of the menu are: 1) file selection, 2) configuration of the 1541 Ultimate cartridge.

The menu starts with showing the available network interfaces, and the storage devices that are attached to the cartridge. By default, it will only show the built-in Ethernet port. When USB-sticks are inserted, one or more items will appear in this list. This screen is the 'root' of the file system. Use the cursor keys to navigate through the file system and select your file (disk image) to mount. The highlighted line shows the current selection.

Use the keyboard as follows:

Key	Function
CRSR up/down	Move the cursor (highlighted line) up/down
CRSR left	Go one level up (leave directory or disk)
CRSR right	Go one level down (enter directory or disk)
Return	Bring up a context menu with actions to be performed on the selected item.
F1	Page up
F7	Page down
F5	Bring up a menu with actions to be performed.
F2	Enter the setup menu
F3	Shows the HELP-text
Space	Select / deselect entries in the file browser for copying.
C=C / C=V	Can be used to copy files between locations, just like in Windows. Be aware that file copy is a lot slower than on a modern PC.
RUN/STOP	Leave the menu.
Quick seek:	Use the keyboard to type the name to search for. You can use '?' as a wildcard.

1.5 More about mounting disks

Remember that 'mounting' a disk means creating a link between the 1541 part of your ultimate cartridge, and a file on a storage device. This means, that when the link has been established, "writes" that the 1541 performs will be written back into the disk image file as well. In this way, the 'real' behavior of a floppy is emulated.

This behavior will not always be what you want. There are two options to avoid this: 'mount' the floppy as read-only, or 'mount' the floppy in 'unlinked' mode. When write protected, the drive itself cannot write to the floppy. In unlinked mode, the writes to the floppy are performed, but do not reflect in the .D64 or .G64 file. When the storage device is removed, the 1541 drive automatically switches to unlinked mode. Be aware that writes to the disk will then be lost when you turn off the machine.

1.6 LEDs

The Ultimate-II+ has four LEDs that are visible on the outside of the plastic case:

1. Green: 1541 drive power

2. Red: 1541 drive status

3. Yellow: Cartridge active

4. Green: Storage activity

The drive power LED has four states:

- Off: The drive is not powered

- Dim: Powered, but no disk mounted

- Half bright: Powered and disk mounted, motor off

- Bright: Powered, disk mounted and motor running.

1.7 Cartridge Emulation

Because the Ultimate-II+ will occupy your cartridge slot, a list of popular expansions available for the C=64 are integrated into the Ultimate-II+. These expansions include cartridges such as the Action Replay, Retro Replay, The Final Cartridge III, Super Snapshot V5, KCS Power Cartridge and the Epyx fastloader. In the configuration menu, even the CBM1750/1764 RAM Expansion unit can be enabled, with expansion RAM up to 16 MB!

Many of these cartridges have a reset button and a freezer button. This is the function of the other two buttons on the Ultimate-II+. By default, the left button is the freezer button, and the button on the right is the reset-button. Through the configuration menu, the buttons can be swapped if desired.

1.8 Configuration

As mentioned above, you can enter the configuration menu by pressing 'F2' while you are in the menu structure. This will bring up a screen with the following items:

- Clock Settings
- Audio Output Settings
- Software IEC settings
- C64 and cartridge settings
- User Interface Settings
- 1541 Drive Settings
- Network Settings

Use the UP/DOWN cursor keys to navigate and RIGHT to enter the desired configuration screen. Once inside a settings screen, the behavior of the keyboard is slightly different:

Key	Function
CRSR up/down	Move the cursor (highlighted line) up/down
CRSR left/right	Increase or decrease a setting, cycling through the available options.
DEL	Go one level up
Return / Space	For string fields: bring up a text entry box For enumerated fields: bring up a context menu with the available options
Run-stop[2]	*Leaves* the configuration menu and saves the new values.

Note that some values will only take effect after reset or a power cycle of your C=64. However, the main menu provides a way to restart the 1541 and the C=64 with the new settings.

1.9 Ethernet

Some of you may be familiar with the RR-net solution that brings Ethernet to the C-64. Currently, the built-in Ethernet port does *not* provide RR-net compatibility. However:

The Ethernet port is used natively by the firmware. There is some primitive support for file-transfer using FTP (needs improvement), and it is possible to connect to the Ultimate-II+ using a VT-100 terminal program on the Telnet port

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[2] On VT-100, use backspace instead of RUN STOP

(port 23). This gives the possibility to control the machine remotely, and swap disks without actually interrupting the program running on the C-64.

1.10 USB support

The Ultimate-II+ supports most USB sticks and Flash card readers out of the box. It also supports USB 2.0 Hubs. It is recommended to use powered USB hubs only (with an external power supply). USB 1.1 Hubs are *not* supported.

There are three USB 2.0 ports available on the cartridge; two on the right and one on the left side. Please note that the port on the left is **not** a USB 3.0 port. Although you may use this port as a 2.0 port, it is not USB 3.0 compliant. The extra signals on a USB 3.0 connector are used to communicate with the tape port (see below). **Please do not attempt to attach a USB 3.0 device to the blue USB connector on the Ultimate-II+.** You may safely use a USB 3.0 device on the *right* side of the cartridge.

1.11 File Systems

Currently, the Ultimate-II+ supports the FAT16/FAT32 file system on any storage device, and the ISO9660/Joliet on CD/DVD ROM drives, or ISO files. It is able to read D64 files, as well as D71 and D81 files (no partitions), T64 files.

1.12 DMA loads

The Ultimate-II+ is capable of loading files directly through the cartridge port into the memory of your C=64. This is called DMA load. The menu supports loading files of the .PRG type only. It doesn't matter if the PRG is located on the FAT/ISO file system, or inside a disk image (.D64), or inside a tape archive (.T64). Be aware that a lot of programs inside a .D64 file require that the rest of the disk is mounted in the drive. For those programs, use the 'Mount & Run' command.

1.13 Tape Support

The Ultimate-II+ is capable of emulating a cassette tape deck (CBM1530/1531). To use this function, a special adapter set connects the Ultimate-II+ to the tape port of your C=64 computer. This tape adaptor set can be purchased separately.

In order to play a tape, browse in the menu to a .TAP file, and press enter and select "Play Tape" from the popup menu. This will initialize the tape streamer from the start of the tape. Use functions in the main menu (F5) to pause/resume playback. It is also possible to write the .TAP file to a real tape, using a CBM1530/1531 deck.

The Ultimate-II+ can also capture tape signals into a .TAP file. The 'F5' menu will show you the available options.

1.14 Audio

The green audio connector on the left side of your device provides a stereo line-out signal. In the configuration menu, it can be selected what is routed to the output channels. Available options include:

- Stereo SID;
- Ultimate Audio module (for playing samples);
- Tape read/write pins (for listening to the tape beeps);

- Drive sounds.

Technical note: The emulated stereo SID is taking the CPU writes from the cartridge slot. Unfortunately, there is no way to tell whether the access is made to the I/O region ($D400-$D7FF), or to the RAM below. The necessary signal to differentiate between the two accesses is simply not available on the cartridge port. For this reason, when software uses the RAM in this area, it is possible that you will hear unintended clicks and pops, or even notes.

The blue line-in connector is not yet used at this point.

1.14.1 Ultimate Audio module

The Ultimate Audio module provides 8 simultaneous sampling voices. This module is utilized as part of the Ultimate-II+ firmware for playing Amiga MOD files. This option is available in the context menu in the file browser.

If you like to do some programming yourself using this sampler, you can enable this module in configuration menu. It then appears in the I/O region. The programming interface is fully documented. Documentation can be downloaded from the official website:

http://1541ultimate.net/content/download/ultimate_audio_v0.2.pdf

1.15 Alternate ROMs

The Ultimate-II+ allows you to use other ROMs for both the emulated 1541 drive, as well as the built-in Kernal ROM of your machine. These ROMs are resident (remembered) by the Ultimate-II+ once they are loaded from the file system.

In order to use an alternate ROM, browse in the file system to the binary ROM file that you like to use. The file should have the '.bin' or '.rom' extension. When you press enter, and the file is of the correct size, the option will appear: "Use as..". Kernal ROMs should be exactly 8K, and drive ROMs should be exactly 16K or 32K.

NOTE: When you use an invalid file as Kernal replacement, the C64 will no longer boot. However, even when the C64 gives a black screen, you can still enter the configuration menu in order to disable the Kernal replacement option.

1.16 Software IEC

The Software-IEC module is a serial bus service that can be enabled in the configuration menu. This module provides two additional devices on the Commodore serial bus; the IEC bus:

- Virtual drive that gives direct access to the Ultimate-II+ file system;
- A virtual printer

1.16.1 Printer

The virtual printer is a valuable contribution created by René Garcia. It takes printer commands from the Commodore 64, and creates a black and white image of the printed graphics and text. This image is then saved to the USB flash drive. The full documentation of the printer emulation and all of its capabilities and options is available here:

http://1541ultimate.net/content/download/mps_printer_emulation.pdf

1.16.2 Virtual drive

The virtual drive can only be used to access files of the file system, through the OPEN/CLOSE commands on the IEC bus. By default, the path of the IEC drive is '/Usb0', which is the top most USB connector on the right of the unit. This default path can be changed in the configuration menu. When the USB drive contains a program 'TEST.PRG', it can be loaded with the basic command LOAD"TEST.PRG",10. Similarly, you can save your programs with the SAVE command. When loading the directory (LOAD "$",10), the path will be shown as disk name.

The command channel 15, can currently only be used to change the current directory. Just like on modern systems, ".." is the parent directory and "/" is the root directory:

OPEN 15,10,15,"CD:/USB1/MYPROGRAMS":CLOSE 15

At this point, the virtual drive is not JiffyDOS compliant.

1.17 Ultimate Command Interface

Since some time, it has become possible to control the Ultimate-II+ programmatically through the I/O port of the C64, thus from a program that runs on the machine. This is useful for many things; for example it can be used to access the file system much faster than through the serial bus. But it can also be used to load files from the file system into REU memory for example. The set of commands grows over time and will provide more and more powerful features.

Documentation of the interface itself is available here:

http://1541ultimate.net/content/download/command_interface_v1.0.pdf

Accessing the file system is done through the "DOS" target, which is documented here:

http://1541ultimate.net/content/download/ultimate_dos_v1.0.pdf

1.18 Real Time Clock

For getting correct time stamps on the files that are created on the USB pen drives, the Ultimate-II+ offers a real time clock (RTC) function. This RTC can be set through the configuration menu.

The RTC is powered by a CR2032 battery, which is located inside of the unit. Calculations show that the lifetime of this battery is several years.

1.19 Social Media

For quick answers to many questions regarding your device, you may be interested to join the the Facebook group "1541 Ultimate".

1.20 Firmware Updates

In order to update the firmware, you will need a file with the ".U2P" extension. Such a file can be found in the '.zip' archives found in the download section of the http://1541ultimate.net website, after logging on to the site.

Procedure: Use the Ultimate-II+ file browser to find the .U2P file. Press ENTER, and the option "Run Update" will appear. Select this option and follow the instructions, if any. After running an update, the unit will reset itself completely after about a minute, without any notification. This is normal behavior.

When, for some reason, the update has failed and corrupted the Flash chip; you can start the "Recovery Mode", by holding the middle button while powering on the unit. In the recovery mode, not all features are available, but the "Run Update" feature should work.

1.21 Disclaimer

The 'firmware' on your Ultimate-II+ board consists of a rather large number of functional parts that all work together. Although an insane number of hours have been put into testing and improving the firmware and software, I am very certain that it still has bugs. Some testing work still needs to be done. The device will be improved further as time passes. Check the download section at the website for the newest firmware version. We believe in the end this will sure be the 'ultimate' storage solution for your 8-bit Commodore computer.

1.22 Known issues

- The processing speed of the Ultimate-II+ is currently (V3.2) still quite a bit lower than the Ultimate-II. This is because the Ultimate-II+ platform does not have instruction/data caches still on its embedded processor. The lower speed may cause some situations in which the unit appears to hang, while it is just busy. For example, when the unit is trying to find a free sector on a large USB stick (and note: even 8 GB is already huge!), it may take up to half a minute or so, before the first file can be written, or the first directory can be created. Similarly, when using the printer emulation, the conversion from a bitmap image to a PNG file can take quite some time. This may be solved in a future software upgrade.

Other issues can be found (and reported) here:

http://1541ultimate.net/content/index.php?option=com_issueform&Itemid=24

Ultimate-64 Documentation

2.1 Getting Started

What do I need to get started?

2.1.1 Prerequisites

- Ultimate 64 motherboard
- Power adapter 12V DC (included)
- A case to put your Ultimate 64 in
- A C64 keyboard
- HDMI cable or standard C64 video cable
- USB Pen drive
- Kernal ROM (extract from your Commodore 64 or download online)
- Basic ROM (extract from your Commodore 64 or download online)
- Char ROM (extract from your Commodore 64 or download online)

Optional

- One or two SID chips
- Keyboard risers (for the C64C model case)

2.1.2 Installing

Mounting the Ultimate 64 in a Case

If you have a spare Commodore 64C case, or bought a new case (which is the C64C model as well), you will need keyboard risers. Some of these have loose metal keyboard risers already in them, others have them mounted with pop rivets to a metal shield. If you have the latter, it is recommended to drill the pop rivets to get the risers loose, otherwise they will interfere with the keyboard connector on the Ultimate 64.

A few C64C have the keyboard clipped onto the top of the case. For those you don't need keyboard risers.

If you buy a new case online, be aware that you will need a keyboard as well.

If you have an older case (the breadbin model), the keyboard is mounted in the top of the case, and therefore you don't need keyboard risers.

1. Mount the risers to your keyboard. The left can be farthest to the edge, but the right riser you have to mount a bit to the left of the right edge, so it won't interfere with the keyboard connector.

2. There are some places online where you can find risers that are supposed to fit perfectly with the Ultimate 64. Here is one model that should work: https://www.thingiverse.com/thing:3051450 You can 3D-print them yourself or ask someone to do it for you. These can be screwed directly onto the bottom of the case as well.

3. Set the keyboard aside for now.

4. Now gently slide the Ultimate 64 board in your case, and fit it to the right side of the case first. The joystick connectors should slide in easy.

5. Push it gently against the back of the case, and let the connectors on the back of the board fit through the holes.

6. Adjust the board so you can see the mounting holes on the bottom of the case through the Ultimate 64 board mounting holes.

7. Fasten the board with suitable screws. Don't tighten too much.

8. Put the keyboard in the case, and connect it to the connector to the right. It will only fit one way, as there are a key pin on the connector.

9. Attach the top of the case.

Accessories

If you have a 3D printer, or you know someone who has, you can find many nice accessories at thingiverse. Here are a few of them:

- Ultimate64 Keyboard Mounting Brackets
- Ultimate64 & C64 Reloaded power connector cover
- Ultimate64 Multi-Button (Power Button) cap
- Ultimate64 board support clips

Connecting your Ultimate 64

Connect your Ultimate 64 to the wall and your TV/monitor. If you start with HDMI, your TV/monitor have to be DVI capable over HDMI. You can change this to HDMI later.

Flashing ROM

Before you can use your Ultimate 64, you have to flash your Kernal and Basic ROM to the Ultimate 64. Power on and wait for picture, where it explains how to do.

Basically you stick your USB drive in the back of the Ultimate 64 and push shortly on the power button to bring up the Menu.

The ROMs has to have the suffix `.bin` or `.rom`, as in mykernal.bin, mybasic.bin, mychar.bin.

1. Browse to your Kernal ROM image and press Enter.

2. Choose `Flash as Orig. Kernal ROM`.

3. Browse to your Basic ROM image and press Enter.

4. Choose `Flash as Orig. Basic ROM`.

5. Browse to your Character ROM image and press Enter.

6. Choose `Flash as Orig. Character ROM`.

7. Push `F5` and choose `Reboot C64`.

Real SID

If you're installing real SID chips, you have to set the jumpers accordingly. If you don't have or don't want to install SID chips you can use the built in 'UltiSID'.
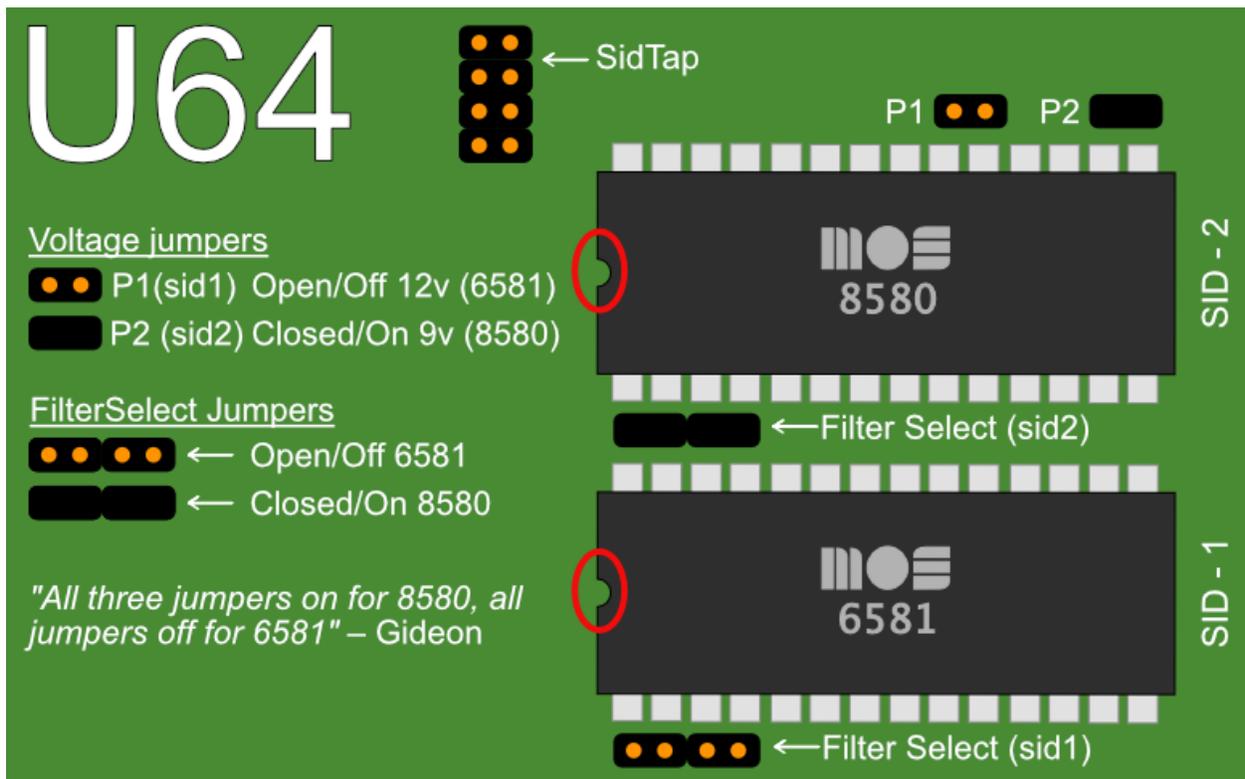

```
Voltage Jumpers:
P1: SID 1 Voltage
P2: SID 2 Voltage
```

```
On/Closed: 9V (8580)
Off/Open: 12V (6581)

Filter Select Jumpers:
On/Closed: 8580
Off/Open: 6581
```

Now you have to set your SID types in the Ultimate-II+ menu:

```
Short press on power button
F2
U64 specific settings
```
Set your types at
```
SID in socket 1
```
and
```
SID in socket 2
```

Setting the SID type in the configuration enables the bus access to the chip, and also allows the auto-configurator to choose the right chip when playing a SID tune with the provided player from Wilfred Bos.

2.2 Multi Button

The Ultimate-64 has one button on the side of the board, which is placed on the original position of the power button.

This button is called the MultiButton, because it handles several functions.

Function	Description
Power on	When the machine is off, press the button briefly to switch it on
Power off	Press the button for 4 seconds to switch off the machine.
Reset	Press the button for about 1 second to reset the machine.
Menu	Press the button briefly to enter the File Selection (Ultimate) menu.
Freeze	Hold the button and briefly tap on the RESTORE key to get into the freeze function of the selected utility cartridge.

2.3 User Interface

The Ultimate-64 provides a user friendly menu driven interface, which can be accessed by pressing the multi button (power) briefly.

There are two modes in which this user interface can operate:

1. Freeze mode

2. Overlay mode

In Freeze mode, pressing the power button briefly will interrupt the currently running program on the C=64 and show the menu. Leaving the menu will resume the C=64 gracefully. This mode of operation works on both PAL and HDMI outputs.

In Overlay mode, pressing the power button briefly will show the menu in an overlayed area on the screen. The C=64 will simply continue running, but the keyboard is switched over to the Ultimate application, as long as this overlay screen is visible. Pressing run-stop in the file browser, or pressing the power button again briefly will make the overlay disappear.

The user interface has three main functions:

1. File browser

2. Configuration of the Ultimate 64 (F2)

3. Tool menu (F5)

2.3.1 File browser

The menu starts with showing the available network interfaces, and the storage devices that are attached to the cartridge. By default, it will only show the built-in Ethernet port. When USB-sticks are inserted, one or more items will appear in this list. This screen is the 'root' of the file system.

Use the cursor keys to navigate through the file system and select your file (disk image) to mount. The highlighted line shows the current selection.

2.3.2 F2 - configuration menu

Use the UP/DOWN cursor keys to navigate and RIGHT to enter the desired configuration screen. Once inside a settings screen, the behavior of the keyboard is slightly different:

Key	Function
CRSR up/down	Move the cursor (highlighted line) up/down
CRSR left/right	Increase or decrease a setting, cycling through the available options.
DEL	Go one level up
Return / Space	For string fields: bring up a text entry box For enumerated fields: bring up a context menu with the available options
Run-stop	*Leave* the configuration menu and saves the new values.

Note that some values will only take effect after reset or a power cycle of your C=64. However, the main menu provides a way to restart the 1541 and the C=64 with the new settings.

2.3.3 F5 - Tool / Command menu

The purpose of the tool menu is to command the Ultimate application to do something that is not related to the selected entry in the file browser menu. For instance, creating a new disk image or directory is such an 'action' that can be performed using the tool menu. Some options might appear / disappear, depending on the state of the application, or based on whether the current file browser directory is writable. For instance, Create Directory is available only when the file browser is in a location were directories can be created.

More information about each of the available options can be found in the description of the Ultimate Application itself, with all of its features.

2.4 Audio/Video Connector
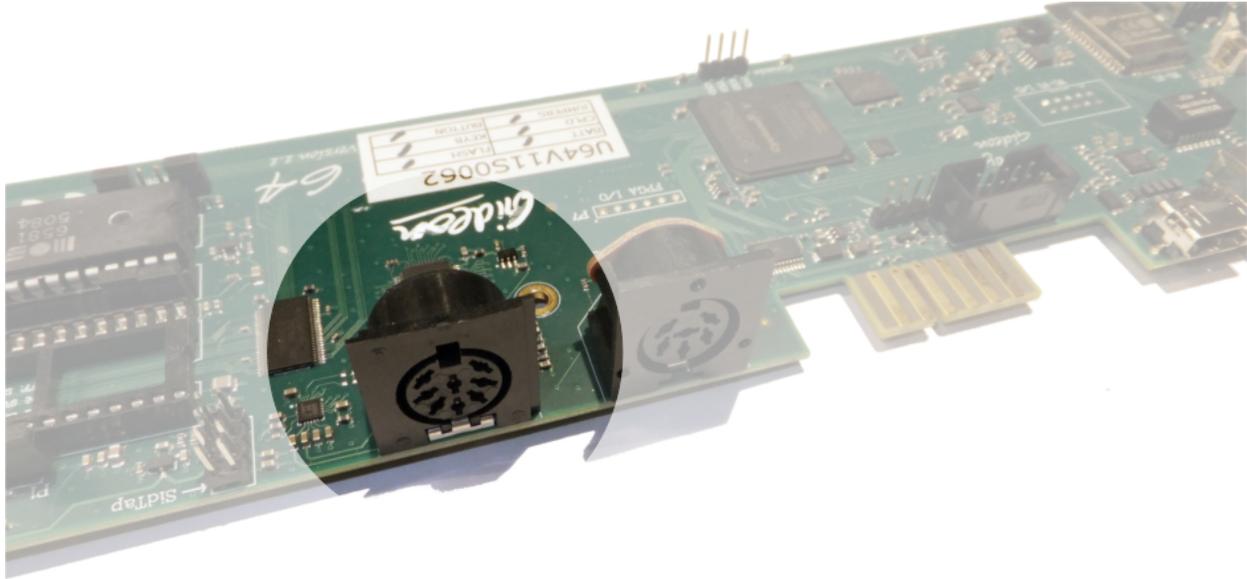
The 8-pin DIN (audio/video) connector can output several different video signals, for each type you need a special assembled cable.

Output signals

- Composite (CVBS) (PAL)

- S-Video (PAL)

- RGB (PAL)

The Composite and S-Video cables are the same as you use for the original Commodore 64.

2.4.1 Pinout

Pin	Modulated Color	RGB Mode
1	Luma (Y)	Green
2	Ground	Ground
3	Audio Out Left	Audio Out Left
4	Composite (Y+C)	Red
5	Audio Out Right	Audio Out Right
6	Chroma (C)	Blue
7	Not used	CSync
8	Not used	Fast Switching
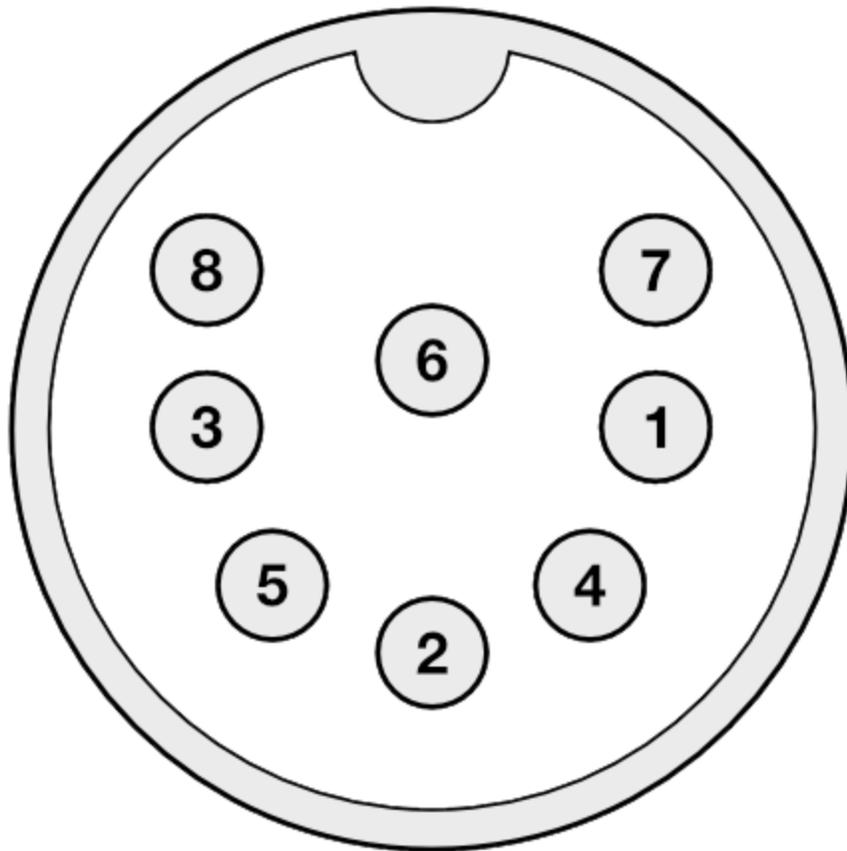
2.4.2 Audio

The audio outputs have consumer electronic line levels (Line Out) and need to be connected to an external amplifier.

2.4.3 Video

The video signals on pin 1, 4 and 6 have a source impedance of 75 Ohms, with standard 1V-peak video levels. In the modulated color mode, Luma and Composite contain sync information (-0.3V), while Chroma does not. The video blanking of the VIC output has been corrected, and is now in accordance with specification.

The PAL output is non-interlaced, with a field rate of 50.2 Hz, and line rate of 15.639 kHz.

The Fast Switching output is a 1.5V fixed 'high' output signal (when terminated with 75 Ohms), that is used on SCART to enable RGB mode. The CSYNC output is a sync-only output that is needed on the SCART signal as a replacement of the composite video or luma signal. In RGB mode, there is *no* sync information in either R, G or B; i.e. no 'sync-on-green'.

2.5 SID-TAP header

Function	Pin	Pin	Function
SID 2 OUT	1	2	Ground
Ground	3	4	SID 2 IN
Ground	5	6	SID 1 IN
SID 1 OUT	7	8	Ground

The SID-TAP header provides a direct (analog) output from the installed SID chips. This header is meant for the purists, who do not want the SID signals to be processed by the U64 board. It is possible to attach a 3.5mm jack plug directly to the SID OUT signals (left column of the header) and use it as a line-out source.

The SID inputs are not often used. However, if you like to use them, you can use the same trick, and attach a 3.5mm jack plug to the right side of the header. This connection provides a line-in connection to your SIDs. This has *not* been functionally verified!

Note that the arrow on the board points at pin 2. In other words, the image and table above are the top view of the header.
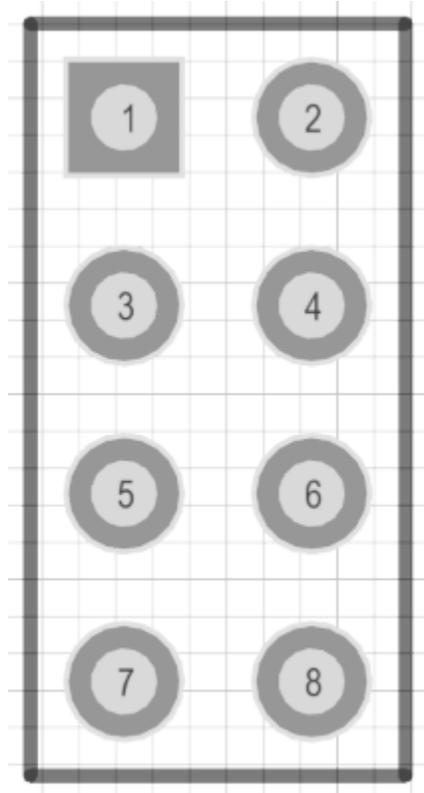
2.6 USER PORT
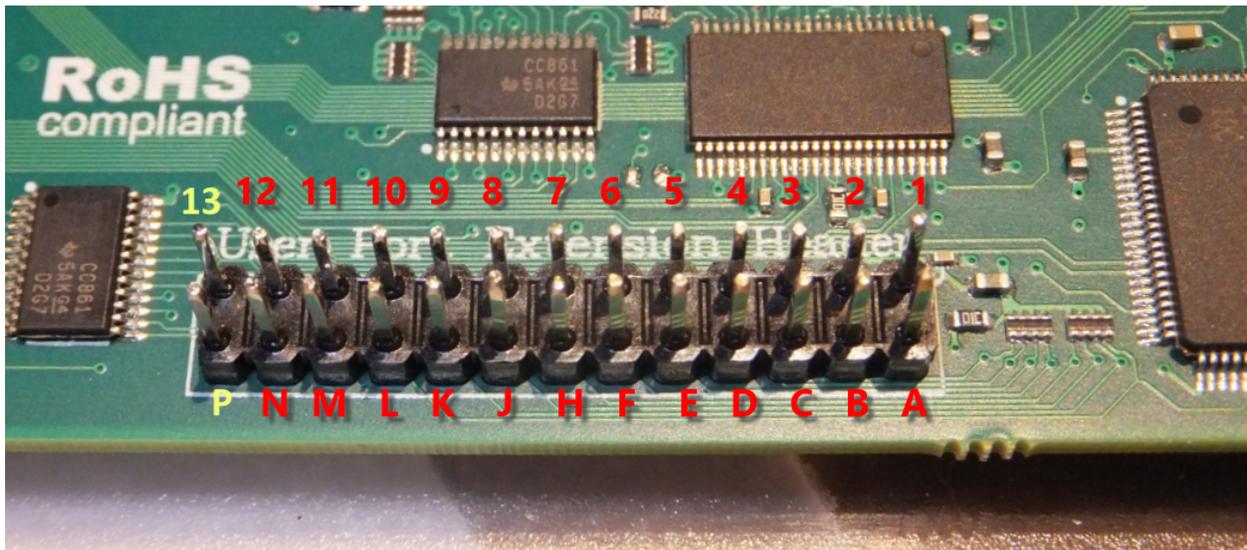
User Port Extension Header

Pin	Name	Description	Special Purpose
1	GND	Ground	
2	+5V	+5 VDC (200 mA max)	
3	/RESET	Reset, will force a Cold Start. Also a reset output for devices.	
4	CNT1	Counter 1, from CIA #1	
5	SP1	Serial Port 1, from CIA #1	
6	CNT2	Counter 2, from CIA #2	
7	SP2	Serial Port 2, from CIA #2	
8	/PC2	Handshaking line, from CIA #2	
9	ATN	Serial Attention	
10	12VDC	12VDC (Max 500mA)	
11	12VDC	12VDC (Max 500mA)	
12	GND	Ground	
13	USRCTL0	FPGA Pin, *NOT* 5V tolerant!	LED Clock
A	GND	Ground (RS232: GND)	
B	/FLAG2	Flag 2 (RS232: RxD=Both B+C)	
C	PB0	Data 0 (RS232: RxD=Both B+C)	
D	PB1	Data 1 (RS232: RTS)	
E	PB2	Data 2 (RS232: DTR)	
F	PB3	Data 3 (RS232: RI)	
H	PB4	Data 4 (RS232: DCD)	
J	PB5	Data 5	
K	PB6	Data 6 (RS232: CTS)	
L	PB7	Data 7 (RS232: DSR)	
M	PA2	PA2 (RS232: TxD)	
N	GND	Ground (RS232: GND)	
P	USRCTL1	FPGA Pin, *NOT* 5V tolerant!	LED Data

Applies to: Ultimate 64

Note that the row 1-12 corresponds to the upper row of the User Port card edge fingers on a C64, and that the row A-N corresponds to the bottom row of the User Port card edge fingers.

Pin 13 and P, the two left most pins on the header, are added for add features to the user port. One of the intended usages of these two pins is the generation of the "9 V~" on the user port extension board.

There is one other use in a special firmware version at the moment of pin 13 and P, which is the control of a LED Strip. In this case, pin 13 the LED Clock and pin P is the LED Data, assuming a LED strip that is based on APA102C.

2.7 LED Strip

Attaching a LED Strip

With a special version of the firmware, it is possible to attach a programmable LED strip to your Ultimate 64 board. The supported LED type is APA102C, with is a 5V only device with built-in PWM controller for each color, red, green and blue. At the time of writing, the firmware supports up to 64 LEDs, of which 24 are currently used. On a strip with 60 LEDs per meter, this corresponds to 40 cm of length, which is roughly the width of the machine.
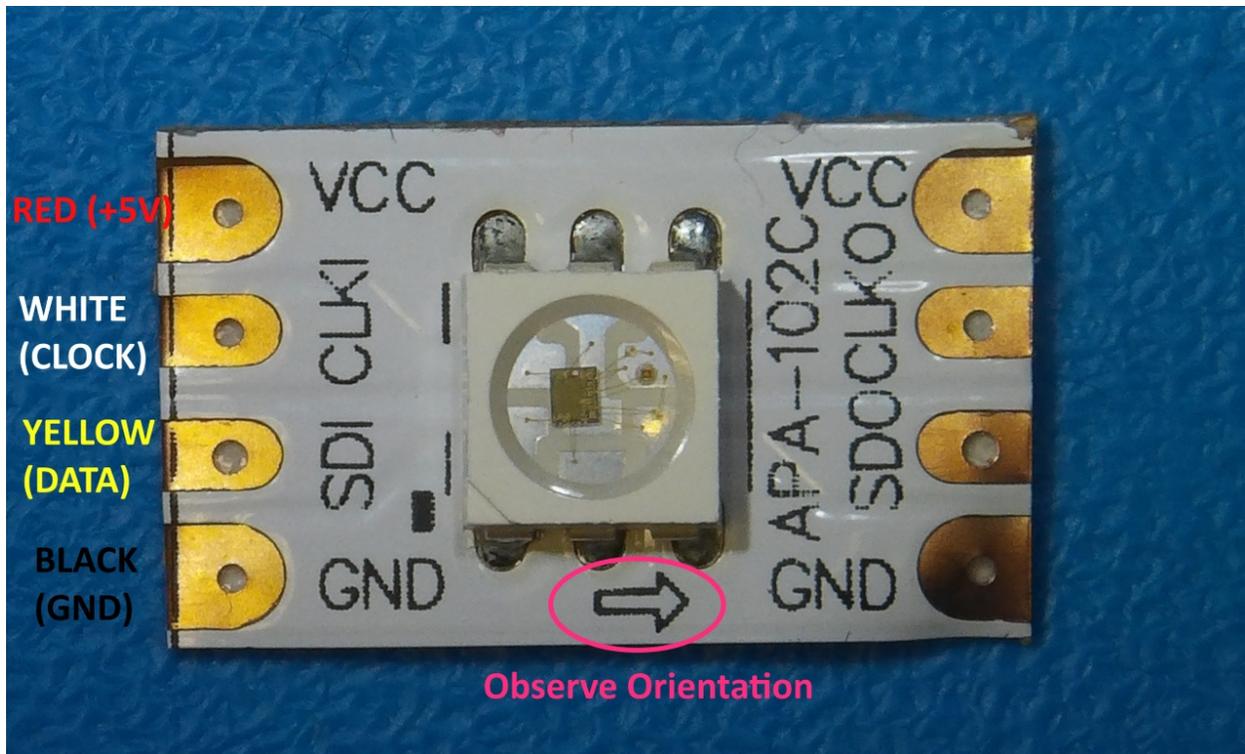
For an easy connection of the LED strip, it is recommended to connect four wires / leads to it, with a single pin socket, like the ones shown below. These wires can be obtained anywhere, and are sold -for example- as Raspberry PI jumper cables.

The following connections need to be made:

Pin	Name	Description	User Port
1	VCC (+5V)	Red wire	Pin 2
2	CLKI	White wire, Clock input	Pin 13
3	SDI	Yellow wire, Data input	Pin P
4	GND (0V)	Black wire	Pin 1, 12, or N

Note, the wire colors are just suggestions. Obviously it will work with other colors as well. But for the sake of not making mistakes, please at least use black and red for ground and +5V respectively.

Please refer to the drawing of the user port header, in order to see where to connect your wire leads. *USER PORT*.

FAQ for the Ultimate II and Ultimate II Plus cartridges

The **Ultimate** cartridge is a storage solution for your Commodore 64 home computer and will give you an excellent experience using this great machine. Some people even enjoy using the Ultimate cartridge with their Commodore 128 computer.

CONTENTS

- *Can I copy files from a disk image to another disk image?*
- *How do I rename files and directories on the file system?*
- *Where are the manuals for the Ultimate II and Ultimate II + carts?*
- *Where are the manuals for the included emulated cartridge images?*
- *Disabling the internal C128D drive*
- *Flip/swap disk (mount the next disk without entering the Ultimate menu)*

3.1 Information and resources for the Ultimate devices

Please read Gideon's story about the Ultimate products. Read the specifications of the Ultimate-II Pluscartridges. Read the announcement of the Ultimate-64 device and the update. Also read the Ultimate-64 project status.

You can buy Gideon's products in his web shop. You can also buy accessories.

3.2 Where can I find the latest firmware?

You can find an overview of almost all firmware releases on this page: firmware overview (including the latest).

3.3 I am still running firmware 2.6k or lower on my U2. How can I upgrade?

Upgrading from 2.6k to 3.x is a bit different from what you're used to. You will first need to upgrade to version 1541U-II Update 3.0 beta 7 using the update.bin in the root of your microSD card.

Once you've done this, you can download latest firmware and run the file that ends with .u2u to upgrade.

To revert to version 2.6k, use the revert.u2u that's included in the 3.0 beta 7 archive.

You can find the 3.0 beta 7 on 1541ultimate.net. and the latest firmware is available in the pinned post at the top of the 1541 Ultimate facebook group or on this page.

3.4 How can I use the emulated SID as second SID for 2SID tunes?

The question: link to facebook posting.

I'm looking for information on how to use the emulated SID of the U2+ together with a real one to play 2SID files, but so far haven't found enough to make it happen. I've fiddled with the settings and read the Sidplayer instructions but all I get is one (the C64 mainboard) Sid. Anyone know where I should look?

1. Find out what address the second SID is using for the 2SID you'd like to listen to. The ultimate sid player that's included shows the second sid address since firmware 3.2.

2. Go to the Ultimate menu and press F2 (shift + F1) to enter the configuration menu.

3. Select 'Audio Output settings'

4. Enable SID Left

5. Change the address at SID Left Base to the address you saw in the ultimate sid player. Probably something like $D420 or so

6. Go to 'SID Left Combined Waveforms' and choose the model the 2SID tune was composed for. Most likely 8580.

7. Go to the Left Channel Output and Right Channel Output and select for both 'Left SID'.

8. Make sure to plug a mini-jack in the line-out mini-jack port and connect it to your powered/active speakers or an amplifier.

9. Run the 2SID file and have a listen ;-)

Btw, the address of the SID chip inside your c64 is $D400.

3.5 Does the U2 and U2+ support Easyflash Cartridge images?

Yes, both carts support EF. Since firmware 3.2 there is also support for saving to the EF cartridge image:

Technology Preview: EAPI Support for Easyflash, incl. but not limited to writing support. Please note that the changed crt file is NOT saved autmatically. You can save it by "F5", "Save Easyflash crt" in the filebrowser (and optionally renaming the saved file).

3.6 Which USB2LAN adapters are supported by the 1541Utlimate 2?

Any USB2LAN adapter that uses an AX88772/-A/-B chip should work.

3.7 Can I control the Utlimate using a USB keyboard?

Yes you can!

You can connect a USB keyboard to the Ultimate cart and use that to control the Ultimate instead of using the buttons. Use the **scroll lock** key to enter the Ultimate menu and **ESC** will bring you back to the basic screen. You can use the keyboard to navigate the Ultimate menu, just like when you're using the remote interface via telnet, or using the C64 keyboard.

3.8 Can I play SID files from the High Voltage Sid Collection?

Yes, the **Ultimate** comes with a built-in SID Player called

3.9 How do I use the built-in SID player

The new Sidplayer in firmware 3.2 has now keyboard support for the following keys:

key	description
	fast forward
1 - 0	sub tune selection for tune 1 - 10
+	play next sub tune
–	play previous sub tune
run/stop	go to Ultimate menu

Keyboard support only works for PSID tunes and for RSID tunes that don't run in a loop and when there is enough memory for the player. If the keyboard doesn't work for a particular tune, then press the cartridge button (default middle button) to go to the Ultimate menu for selecting another SID or sub tune.

3.10 Can I play SID tunes using the network interface?

There are several ways to play SID tunes using the ethernet interface:

- Use the remote interface using telnet;
- Use the Acid 64 Player Pro SID player by Wilfred Bos.

This SID player has the ability to play SID tunes over the netwerk on the Ultimate devices. It is built to run on the Microsoft Windows Operating System. When using Wine, Acid 64 Player Pro will also run on macOS and Linux.

- Use Ultimate1541 Sid Remote 1.1 by L.A. Style of Genesis Project. This software runs on Microsoft Windows Operating system.

3.11 How do I use T64 files?

T64 is a file format, or rather a container, just like D64 disk image. Unfortunately the U2 and U2+ does not recognise it as such. This means that you cannot open this container using the return key and then choose enter.

Instead, you can use the right cursor key to enter the T64 container and then press return to have the contextual menu pop up and choose run to run the c64 programme.

3.12 How do I create a create a directory

To create a directory on the file system browse to the location you would like to create a directory. Press F5 and choose the 'Create Directory' from the contextual menu.

3.13 How do I create a blank disk image

To create a blank d64 or g64 disk image on the file system browse to the location you would like to create a directory. Press F5 and choose the 'Create D64' or 'Create G64' from the contextual menu.

3.14 How do I copy a disk image, directory or file to another location

You can copy d64 disk images, directories and even files from inside a disk image to the file system. Unfortunately you cannot (yet) copy a file from the file system into a disk image. Also, if you copy a file from inside the disk image

to the file system, make sure to give it an appropriate extension. The U2 / U2+ doest not (yet) do this by itself, unless you run this unofficial firmware by MarkusC64.

The keys to use are:

- use space bar to select the file(s) / dir(s) you'd like to copy

- use cbm + c to copy

- use cbm + v to paste.

3.15 Can I copy files from inside a disk image to the file system?

Yes, you can copy files from inside a disk image to the file system.

1. Highlight the disk image;

2. Press either return and then select 'enter' or use right arrow key to enter the disk image;

3. Select one or more files you'd like to copy by pressing the space bar;

4. Use cbm + c to copy the file(s);

5. Leave the disk image by using the left cursor key;

6. Go to the location you'd like to paste the file and use cbm + v to 'paste' the file(s).

When using an old firmware, you will need to add the file extension yourself. Just press return and choose 'rename' to do this.

3.16 Can I copy files from the file system to a disk image?

Unfortunately this is not possible. Perhaps in a distant future firmware release this will be possible.

3.17 Can I copy files from a disk image to another disk image?

Unfortunately this is not possible yet. If you try to copy a file either from the file system or a disk image and paste it into another disk image, the 'paste' programme will crash and most likely you will need to reset or reboot your C64.

3.18 How do I rename files and directories on the file system?

To rename either a file or a directory simply select the file or directory and press enter. A contextual menu will pop-up, select 'rename' to rename the file.

3.19 Where are the manuals for the Ultimate II and Ultimate II + carts?

Unfortunately there are no manuals in a sense that you can read about all functions, settings etc. of the Ultimate cartridges.

For both the Ultimate II and Ultimate II+ a quick start guide exists.

A resource for some documentation can be found here: http://rr.c64.org/wiki/1541_Ultimate#Documentation

3.20 Where are the manuals for the included emulated cartridge images?

You will need to google for that. Archive.org seems to have scans of several c64 cartridges.

The wiki rr.c64.org is also a great place to find some manuals.

3.21 Disabling the internal C128D drive

source: 1541ultimate.net forum

Most of the games will only run from device #8. Even if you added a device number 8/9-Switch to your internal C128 drive, some games and demos do not like if there is a 2nd drive on the bus.

So, the good news: With S.T.F.U. you can disable your internal drive by software: https://csdb.dk/release/?id=160842)

1. Set your 1541-U drive emulation to device #9 or OFF

2. Start and run the file. (In my case I had to load it from disk - it does not seem to work if you DMA-start it from your 1541-U).

3. Select and deactivate your internal 1571.

4. Set your Drive A of your 1541-U to device #8 and use it as regular drive.

This did work on my C128D. It did not work on my SX64. However it might be of interest for C128D users.

3.22 Flip/swap disk (mount the next disk without entering the Ultimate menu)

Since firmware 3.0e there is this nice feature implemented by Markus C64: "seamless disk swap by pressing middle button at least 1 sec"

This allows you to mount the next disk when a game or a demo asks for it without entering the Ultimate menu.

It only works on disk images for which it is obviously that those disk images belong together E.g. "special game disk 1.d64" and "special game disk 2.d64" or "special game A.d64" and "special games B.d64" or "special game S1.d64" and "special game S2.d64". or "image 1.d64" and "image 2.d64", etc. etc. etc. It even recognises roman numbers.

CHAPTER 4

Command Interface

4.1 Introduction

4.1.1 Context

The 'Ultimate-II command interface' feature is a new feature for the 1541 Ultimate-II module. It implements a way to communicate to the 1541 Ultimate-II programmatically from the Commodore 64, through the cartridge port I/O registers.

The 'Ultimate-II command interface' is the communication layer between the C64 on one side and functional modules of the 1541 Ultimate-II on the other side. Such a functional module takes a command, and returns data and status back to the user program on the C64.

Initially, there is one functional module, named "Ultimate DOS", which is described in a separate document.

4.1.2 Purpose of this document

The 'Ultimate-II command interface' feature is accessible from the cartridge I/O range. In this manual, the programming API is described.

4.2 Transport Layer

4.2.1 Overview

The transport layer of the Ultimate-II Command Interface makes use of a register interface which is accessible through the cartridge port of the C64. The registers are mapped into I/O space, at the address $DF1C up to $DF1F, masking the last four registers of the RAM Expansion Unit (REU). Mapping this small 4-byte block into the I/O space is optional, and needs to be turned on in the 'Command Interface' configuration menu.

4.2.2 Register Overview

The following table shows the four registers and their meaning.

Address	Description	Default
$DF1C	Control register (Write)	
$DF1C	Status register (Read)	$00
$DF1D	Command data register (Write)	
$DF1D	Identification register (Read)	$C9
$DF1E	Response Data register (Read only)	
$DF1F	Status Data register (Read only)	

4.2.3 Communication Protocol Basics

The communication protocol is based on a state machine with four states:

- Idle
- Command Busy
- Data Last (last block)
- Data More (more data pending)

The transition through these states takes place in an interaction between the C64 user software and the software running on the Ultimate-II. The state that the communication protocol is in can be read from the Status register at $DF1C.

Transfer command

When the protocol is in idle state (see paragraph 2.4.2 for the state encoding), the Ultimate-II is ready to receive a new command. This is done by writing the command byte by byte into the command data register at $DF1D. Then, the command is pushed into the Ultimate-II by writing a '1' to the control bit 'PUSH_CMD', in the control register. This will cause a state transition to "Command Busy".

Ultimate-II processes command

As soon as the Ultimate-II has decided how to respond to this command, it will prepare the data and status reply, and cause the state machine to move to one of the two data states: 'Data Last', or 'Data More'.

Reading the reply

The user software can now read both data and status from the respective registers $DF1E and $DF1F. Whether there is data or status available can be seen from the upper two bits of the status register. These bits will be '1' when there is still more data to be read, and '0' otherwise.

Release: Accept data

As soon as the software has read all the data (or decides not to do so), the C64 should write a '1' to the register bit 'DATA_ACC', to indicate that all data was accepted. If this was the last data block, this causes the state machine to go back to the idle state, or else, the state returns to "Command Busy".

State machine

The following diagram shows the state machine:
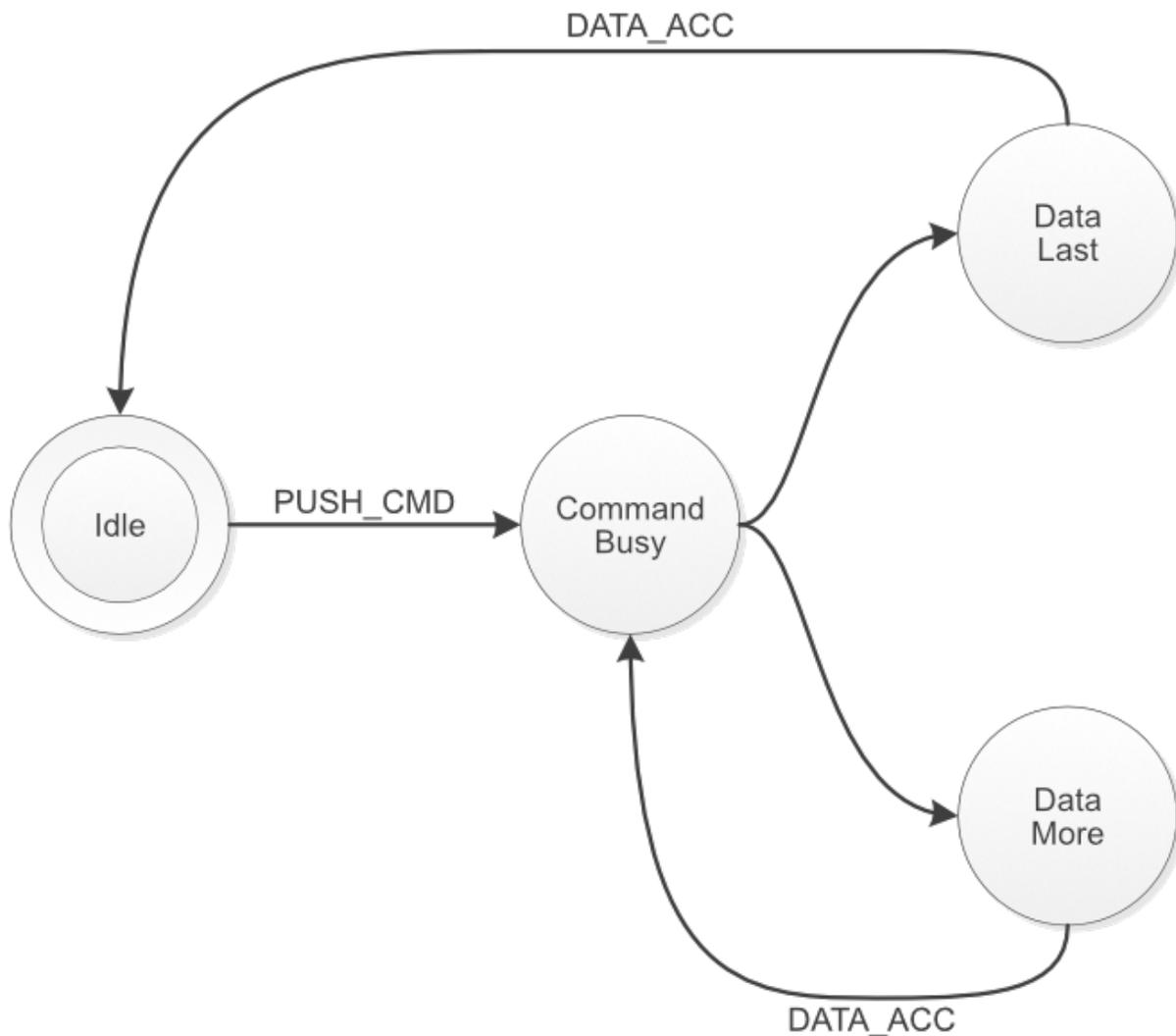
Figure 1: Basic Protocol State Machine

Note: Setting the 'ABORT' bit, does not directly influence the state machine. It is handled by the Ultimate-II software, which will in turn reset the state machine to idle eventually.

4.3 Register Details

4.3.1 Control Register

The control register contains the following bits:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
reserved				CLR_ERR	ABORT	DATA_ACC	PUSH_CMD

PUSH_CMD: Writing a '1' to this register bit causes the command that was written to the command data register to be pushed into the software of the Ultimate-II.

DATA_ACC: Writing a '1' to this register bit tells the communication layer that all data from the Ultimate-II was accepted. This is automatically ignored when the communication controller is not in one of the two data states. Writing to this bit also causes the transfer of the data/status queues to be aborted and reset. Thus, the data response and status response queues will be empty after writing this bit.

ABORT: Writing a '1' to this register sets the 'abort' flag in the communication controller. This bit is polled by the Ultimate-II software. When it finds this bit set, the current communication is aborted, and the state machine is forced back to the idle state.

CLR_ERR: Pushing a command to the Ultimate-II when the communication layer is not in idle mode, causes a state error flag to be set. See status register. Write a '1' to CLR_ERR to clear this error condition.

Status register

The status register contains the following bits:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
DATA_AV	STAT_AV	*STATE*		ERROR	ABORT_P	DATA_ACC	CMD_BUSY

CMD_BUSY: This bit indicates that there is a pending command in the command memory.

DATA_ACC: This bit reflects the condition that the user has told the Ultimate-II that it accepted the data.

ABORT_P: This bit reflects the state of the internal abort flag. When this bit is '1', the Ultimate-II still has to handle the abort request.

ERROR: When this bit is '1', the user tried to send a command to the Ultimate-II while it was not in idle state.

STATE: These two bits encode the protocol state:

00: Idle

01: Command Busy

10: Data Last

11: Data More

STAT_AV: When this bit is '1', there is status data available from the status queue, accessible through the status data register ($DF1F).

DATA_AV: When this bit is '1', there is response data available from the data queue, accessible through the response data register ($DF1E).

4.3.2 Queues

As previously described, there are three byte-queues that the Ultimate-II Command Interface uses:

- Command queue

- Response Data queue

- Status queue

The sizes of these queues are important to note, since they define the maximum transfer size per command. The command queue size is 896 bytes ($380), the response data queue is also 896 bytes ($380), and the status queue is 256 bytes ($100).

4.4 Dispatch Layer

On top of the transport layer, there is light weight dispatcher. This dispatcher sends the command from the user software to a functional module in the 1541 Ultimate-II. The first byte of the command is determines the destination. Such a destination is called a 'target'.

Initially, in version 2.6 of the Ultimate-II firmware, there is only one functional target: "Ultimate-DOS". Two instances of this DOS are located at targets 1 and 2. See the documentation of this target to obtain more information on the commands this target implements.

CHAPTER 5

Ultimate-II Virtual Printer

By René Garcia Version: February 18th 2018 All rights reserved.

5.1 Introduction

5.1.1 Context

The virtual printer is an Ultimate-II feature since 3.0 firmware. With this functionality you can print from your Commodore 64/128 using a virtual IEC device #4 or #5.

This emulation simulates a Commodore MPS-1230 printer with all the commands that this printer can understand. Not all commands are executed as some of them are hardware related and cannot obviously be implemented. The results are printed to PNG image files, one file per page. You can also choose to bypass the printer emulation and to send the raw data from #4 or #5 IEC device to a file.

MPS-1230 was a mid-range black ink ribbon 9 needle matrix printer sold by Commodore in the late 80's.

This printer is compatible with nearly all the usual programs that have been edited for C64/C128. It can interpret 4 printer instruction sets:

- Commodore MPS-801
- Epson FX-80
- IBM Graphics Printer
- IBM Proprinter

5.1.2 License

Virtual Printer is released under the GNU General Public License 3.0. A full copy of the license is included in the root of the Ultimate-II firmware sources.

5.1.3 Purpose of this document

This document describes how to use and configure the Ultimate-II embedded virtual printer.

You will also find all the commands and charsets supported by the printer. Then you can add printer facility to your own BASIC programs!

5.2 Configuration

5.2.1 Overview

You will find all the configuration items for the printer in the IEC configuration menu.

5.2.2 Enable the printer

To enable the printer, you need to enable the software IEC feature in the Ultimate-II:

- Use the F2 Menu to enter Ultimate-II configuration and then select "**Software IEC Settings**"
- Then on item "**IEC Drive and Printer**" select "**Enabled**"

5.2.3 Printer configuration items

- **Printer Bus ID**: 4 or 5 (default is 4)
  This will assign device ID 4 or 5 to the printer.

- **Printer output file**: (default is */SD/*printer on Ultimate II or */Usb0/printer* on Ultimate II+)
  You can select file base name that the virtual printer will use to create the PNG files. If you choose to generate PNG files they will be named *printer-001.png*, *printer-002.png*, and so on. If you chose the bypass the emulation and write RAW binary data to disk the file will be named *printer* with no extension. When using ASCII filter output, extension *.txt* will be appended to file name.

- **Printer output type**: PNG, ASCII or RAW (default is PNG)
  PNG are images created by the printer emulator each time a page is ejected from the printer. Caution, if a file with the same name already exists, it will not be overwritten and the page is lost. RAW is the data directly sent by the C64/128 to the IEC port and recorded as binary to a file. ASCII will keep and convert printable characters to ISO8859-1 standard. This output only makes sense if you are printing text as you will only get garbage with bitmap. In both RAW and ASCII output mode, if the file already exists, the new data will be appended to it.

- **Printer ink density**: Low, Medium or High (default is Medium)
  You can consider this as "how strong is the pin impact on the paper". *Low* will only print very small dots and *High* larger dots. As a consequence, this will change the resulting contrast. *High* gives the best result for DRAFT character mode. *Medium* may be well suited for NLQ character mode. Just test and see what match your needs. *See table below for samples*.

- **Printer emulation**: Commodore MPS, Epson FX-80, IBM Graphics Printer, IBM Proprinter (default is Commodore MPS)
  You can select which instruction set the emulator will recognize. Changing from one emulation to another will reset the printer attributes but the printer head stays at the same place and the page is not ejected.

- **Printer Commodore charset:** USA/UK, Denmark, France/Italy, Germany, Spain, Sweden, Switzerland (default is USA/UK)

Select which charset to use when using Commodore MPS emulation. If you don't know which one to choose, USA/UK is the one you want. See Commodore charset description on chapter 19.

- **Printer Epson charset:** Basic, USA, France, Germany, England, Denmark I, Sweden, Italy, Spain, Japan, Norway, Denmark II (default is Basic)

  Select which charset to use when using Epson FX-80 emulation. See Epson charset description on chapter 10.

- **Printer IBM table 2:** International 1, International 2, Israel, Greece, Portugal, Spain (default is International 1)

  Select which charset to use for Table2 when using IBM Graphics Printer or IBM Proprinter emulation. IBM printers can use 2 charsets: Table 1 and Table2. Table 1 cannot be modified and is the default charset. Table 2 is the one you chose with this parameter. See IBM charset description in chapter 11.

Ink Density	Low	Medium	High
Elementary Dot (x1)		.	.
Elementary Dot (x300)	■		
Draft text	1541 ULTIMATE II	1541 ULTIMATE II	1541 ULTIMATE II
NLQ text	1541 ULTIMATE II	1541 ULTIMATE II	**1541 ULTIMATE II**
Draft graphic chars	♠ ♥ ♦ ♣	♠ ♥ ♦ ♣	♠ ♥ ♦ ♣
NLQ graphic chars	♣ ♥ ♦ ♣	♠ ♥ ♦ ♣	♠ ♥ ♦ ♣
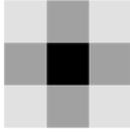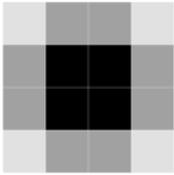
5.3 Using the printer

5.3.1 Printing from the C64/C128

Just use your program and tell it that you have a connected printer compatible with MPS Commodore series (e.g.: MPS-801/MPS-803 are the most frequently supported commodore printers).

5.3.2 Flushing the printer spool

The printer has a very small buffer (256 bytes) and some data may still be in the buffer waiting to be printed when your print job is finished. The printer doesn't know that your job is finished and waits for more data to print until the end of the page.

You need to tell the printer that you want all the buffered data to be printed and to eject the current page. This works as the *Form Feed* button on the real MPS-1230 to eject the page.

Go to F5 Menu and select "**Flush Printer/Eject Page**". In PNG mode, this will make the current page to be written to a file. Next print job will start on a blank page. In RAW and ASCII mode this will write the buffered data to the file.

5.3.3 Resetting the printer

You may need to reset printer to go back to an initial state. Go to F5 Menu and select "**Reset IEC and Printer**". Current data in printer buffer is lost. Current page that was being printed is also lost.

5.3.4 Performances

Composing a page full of text and creating the PNG file will need approximatively 15 seconds on the Ultimate-II (28 seconds using NLQ mode). You may think it's slow but this is much faster than a real MPS-1230 printer (1 min in DRAFT mode, 4 min in NLQ mode) !

The Ultimate-II middle button becomes unresponsive while composing a page. The green LED on the right of the cartridge is lit when printer is working. Be patient and look at the activity LED to stop blinking.

RAW and ASCII modes are nearly immediate. There is no process time to wait.

At this time, with firmware 3.2, The virtual printer is slower on Ultimate II+ than on Ultimate II as it is using a slower CPU. In fact, no processor cache is implemented yet in Ultimate II+, this may change in a future firmware as CPU is implemented in FPGA using VHDL.

5.4 Capabilities

This table summarize the printer capabilities depending on which printer emulation is active:

	Commodore MPS	Epson FX-80	IBM Graphics Printer	IBM Proprinter
Draft	•	•	•	•
Double strike	•	•	•	•
Bold	•	•	•	•
Italic (draft only)	•	•	•	
NLQ	•	•	•	•
Underline	•	•	•	•
Double width	•	•	•	•
Superscript	•	•	•	•
Subscript	•	•	•	•
Reverse	•			

Table 1 – continued from previous page

	Commodore MPS	Epson FX-80	IBM Graphics Printer	IBM Proprinter
Overline				•
Backspace		•	•	•
Reverse page feed		•		
CR=CR+LF	•			*optional*
LF=CR+LF	•	•		
7 dot BIM	•			
8 dot BIM		•	•	•
9 dot BIM		•		
HT Program		•	•	•
VT Program		•		•
60 dpi BIM	• *(double width)*	•	•	•
75 dpi BIM		•		
80 dpi BIM		•		
90 dpi BIM		•		
120 dpi BIM		•	•	•
240 dpi BIM		•	•	•

Continued on next page

Table 1 – continued from previous page

	Commodore MPS	Epson FX-80	IBM Graphics Printer	IBM Proprinter
Pica (10cpi)	•	•	•	•
Elite (12cpi)	•	•	•	•
Micro (15cpi)	•			
Condensed (17.1cpi)	•	•	•	•
Pica Compressed (20cpi)	•			
Elite Compressed (24 cpi)	•			
Micro Compressed (30 cpi)	•			

5.5 Commodore MPS commands

This chapter describes the commands the printer can understand when using the Commodore MPS emulation. You will find Commodore BASIC examples to explain you how to use them. This printer uses PETASCII.

5.5.1 Simple example

This will print a first line with HELLO WORLD! on it and a second line with HELLO printed with double width characters.

10 OPEN1,4

20 PRINT#1,"HELLO WORLD!"

30 PRINT#1,CHR$(14)"HELLO"

40 CLOSE1

HELLO WORLD!
HELLO

5.5.2 Secondary address

Only on Commodore MPS emulation, you can specify an optional secondary address on OPEN :

- **0** : Select PETASCII charset with uppercases and graphic chars
- **7** : Select PETASCII charset with lowercases and uppercases

If no secondary address is specified, 0 is the default.

5.5.3 Commands

For a detailed description of all commands, please refer to the PDF version of this document.

5.6 PETASCII character table

5.6.1 USA/UK

```
   | 0 1 2 3 4 5 6 7 8 9 A B C D E F
 --+--------------------------------
 0 |     0 @ P — ⌐         ⌐ — ⌐     ⌐
 1 |   ! 1 A Q ♠ ●     ▮ ⊥ ♠ ● ▮ ⊥
 2 |   " 2 B R │ —     ▬ ⊤ │ — ▬ ⊤
 3 |   # 3 C S ─ ♥     ─ ⊣ ─ ♥ ─ ⊣
 4 |   $ 4 D T ⁻ │     _ │ ⁻ │ _ │
 5 |   % 5 E U ⁻ ╱     │ ▮ ⁻ ╱ │ ▮
 6 |   & 6 F V ─ ╳     ▨ ▮ ─ ╳ ▨ ▮
 7 |   ' 7 G W │ ○     │ ⁻ │ ○ │ ⁻
 8 |   ( 8 H X │ ♣     ▨ ▬ │ ♣ ▨ ▬
 9 |   ) 9 I Y ╲ │     ◤ ▬ ╲ │ ◤ ▬
 A |   * : J Z ╲ ♦     │ ⌟ ╲ ♦ │ ⌟
 B |   + ; K [ ╱ +     ├ ▪ ╱ + ├ ▪
 C |   , < L £ ⌐ ▤     ▪ ⁚ ⌐ ▤ ▪ ⁚
 D |   - = M ] ╲ │     ⌊ ⌟ ╲ │ ⌊ ⌟
 E |   . > N ↑ ╱ π     ⌐ ▪ ╱ π ⌐ ▪
 F |   / ? O ← ⌐ ◣     _ ⁚ ⌐ ◣ _ π
```

Table : USA/UK Charset in Uppercase/Graphic Mode (Secondary address = 0)

```
   | 0 1 2 3 4 5 6 7 8 9 a b c d e f
 --+--------------------------------
 0 |     0 @ p — P         ⌐ — P     ⌐
 1 |   ! 1 a q A Q     ▮ ⊥ A Q ▮ ⊥
 2 |   " 2 b r B R     ▬ ⊤ B R ▬ ⊤
 3 |   # 3 c s C S     ─ ⊣ C S ─ ⊣
 4 |   $ 4 d t D T     _ │ D T _ │
 5 |   % 5 e u E U     │ ▮ E U │ ▮
 6 |   & 6 f v F V     ▨ ▮ F V ▨ ▮
 7 |   ' 7 g w G W     │ ⁻ G W │ ⁻
 8 |   ( 8 h x H X     ▨ ▬ H X ▨ ▬
 9 |   ) 9 i y I Y     ▨ ▬ I Y ▨ ▬
 a |   * : j z J Z     │ ╱ J Z │ ╱
 b |   + ; k [ K +     ├ ▪ K + ├ ▪
 c |   , < l £ L ▤     ▪ ⁚ L ▤ ▪ ⁚
 d |   - = m ] M │     ⌊ ⌟ M │ ⌊ ⌟
 e |   . > n ↑ N ▚     ⌐ ▪ N ▚ ⌐ ▪
 f |   / ? o ← O ▨     _ ⁚ O ▨ _ ▚
```

Table USA/UK Charset in Lowercase/Uppercase Mode (Secondary address = 7)

5.6.2 Denmark

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0				0	@	P	—	⌐				⌐	—	⌐		⌐
1			!	1	A	Q	♠	●			▮	⊥	♠	●	▮	⊥
2			"	2	B	R	▮	—			▬	⊤	▮	—	▬	⊤
3			#	3	C	S	—	♥			—	⊣	—	♥	—	⊣
4			$	4	D	T	—	▮			_	▮	—	▮	_	▮
5			%	5	E	U	—	⟋			▮	▮	—	⟋	▮	▮
6			&	6	F	V	—	×			▓	▮	—	×	▓	▮
7			'	7	G	W	▮	○			▮	—	▮	○	▮	—
8			(	8	H	X	▮	♣			▰	▬	▮	♣	▰	▬
9			)	9	I	Y	⟍	▮			◤	▬	⟍	▮	◤	▬
A			*	:	J	Z	⟍	♦			▮	⌟	⟍	♦	▮	⌟
B			+	;	K	Æ	⟋	+			⊢	▪	⟋	+	⊢	▪
C			,	<	L	Ø	⌊	▓			▪	▪	⌊	▓	▪	▪
D			–	=	M	Å	⟍	▮			⌞	⌟	⟍	▮	⌞	⌟
E			.	>	N	↑	⟋	π			⌐	▪	⟋	π	⌐	▪
F			/	?	O	←	⌐	◣			▬	▪	⌐	◣	▬	π

Table : DENMARK Charset in Uppercase/Graphic Mode (Secondary address = 0)

	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
0				0	@	p	—	P				⌐	—	P		⌐
1			!	1	a	q	A	Q			▮	⊥	A	Q	▮	⊥
2			"	2	b	r	B	R			▬	⊤	B	R	▬	⊤
3			#	3	c	s	C	S			—	⊣	C	S	—	⊣
4			$	4	d	t	D	T			_	▮	D	T	_	▮
5			%	5	e	u	E	U			▮	▮	E	U	▮	▮
6			&	6	f	v	F	V			▓	▮	F	V	▓	▮
7			'	7	g	w	G	W			▮	—	G	W	▮	—
8			(	8	h	x	H	X			▰	▬	H	X	▰	▬
9			)	9	i	y	I	Y			▨	▬	I	Y	▨	▬
a			*	:	j	z	J	Z			▮	⌵	J	Z	▮	⌵
b			+	;	k	æ	K	Æ			⊢	▪	K	Æ	⊢	▪
c			,	<	l	ø	L	Ø			▪	▪	L	Ø	▪	▪
d			–	=	m	å	M	Å			⌞	⌟	M	Å	⌞	⌟
e			.	>	n	↑	N	▚			⌐	▪	N	▚	⌐	▪
f			/	?	o	←	O	▨			▬	▪	O	▨	▬	▚

Table DENMARK Charset in Lowercase/Uppercase Mode (Secondary address = 7)

5.6.3 France / Italy

```
  | 0 1 2 3 4 5 6 7 8 9 A B C D E F
--+
0 |       0 @ P ` ⌐         §  ` ⌐       §
1 |     ! 1 A Q ◣ ◤       | à  ◣ ◤   | à
2 |     " 2 B R ▬ ⟋       ∟ è  ▬ ⟋   ∟ è
3 |     # 3 C S ▬ ▪       ⊥ ì  ▬ ▪   ⊥ ì
4 |     $ 4 D T ▪ ⟍       ⌐ ò  ▪ ⟍   ⌐ ò
5 |     % 5 E U ▪ ▮       ⊦ ù  ▪ ▮   ⊦ ù
6 |     & 6 F V ⟍ ▬       — â  ⟍ ▬   — â
7 |     ' 7 G W ⟋ ▪       ⊣ ê  ⟋ ▪   ⊣ ê
8 |     ( 8 H X ▮ ▬       ⌐ î  ▮ ▬   ⌐ î
9 |     ) 9 I Y | _       ⊤ ô  | _   ⊤ ô
A |     * : J Z | ▮       ⌐ û  | ▮   ⌐ û
B |     + ; K [ ⟍ ë       + Ä  ⟍ ë   + Ä
C |     , < L \ ∟ ï       £ Ö  ∟ ï   £ Ö
D |     - = M ] ⟋ °       ' Ü  ⟋ °   ' Ü
E |     . > N ↑ ▬ π       ^ ß  ▬ π   ^ ß
F |     / ? O ─ ⌐ ç       ¨ é  ⌐ ç   ¨ π
```

Table : FRANCE/ITALY Charset in Uppercase/Graphic Mode (Secondary address = 0)

```
  | 0 1 2 3 4 5 6 7 8 9 a b c d e f
--+
0 |       0 @ p ` P         §  ` P       §
1 |     ! 1 a q A Q       | à  A Q   | à
2 |     " 2 b r B R       ∟ è  B R   ∟ è
3 |     # 3 c s C S       ⊥ ì  C S   ⊥ ì
4 |     $ 4 d t D T       ⌐ ò  D T   ⌐ ò
5 |     % 5 e u E U       ⊦ ù  E U   ⊦ ù
6 |     & 6 f v F V       — â  F V   — â
7 |     ' 7 g w G W       ⊣ ê  G W   ⊣ ê
8 |     ( 8 h x H X       ⌐ î  H X   ⌐ î
9 |     ) 9 i y I Y       ⊤ ô  I Y   ⊤ ô
a |     * : j z J Z       ⌐ û  J Z   ⌐ û
b |     + ; k [ K ë       + ä  K ë   + ä
c |     , < l \ L ï       £ ö  L ï   £ ö
d |     - = m ] M °       ' ü  M °   ' ü
e |     . > n ↑ N π       ^ ß  N π   ^ ß
f |     / ? o ─ O ç       ¨ é  O ç   ¨ π
```

Table FRANCE/ITALY Charset in Lowercase/Uppercase Mode (Secondary address = 7)

5.6.4 Germany

```
   | 0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
---+------------------------------------------------
0 |          0  @  P  `  ⌐           ə  `  ⌐        `
1 |       !  1  A  Q  ◥  ◤        |  µ  ◥  ◤  |  ◥
2 |       "  2  B  R  ▬  ⌐        └  à  ▬  ⌐  └  ▬
3 |       #  3  C  S  ▬  ▪        ┴  ù  ▬  ▪  ┴  ▬
4 |       $  4  D  T  ▪  ヽ        ┘  â  ▪  ヽ  ┘  ▪
5 |       %  5  E  U  ▪  ▮        ├  ê  ▪  ▮  ├  ▪
6 |       &  6  F  V  ヽ  ▬        —  î  ヽ  ▬  —  ヽ
7 |       '  7  G  W  ノ  ▪        ┤  ô  ノ  ▪  ┤  ノ
8 |       (  8  H  X  ▮  ▬        ┌  û  ▮  ▬  ┌  ▮
9 |       )  9  I  Y  |  —        ┬  √  |  —  ┬  |
A |       *  :  J  Z  |  ▮        ┐  Σ  |  ▮  ┐  |
B |       +  ;  K  [  ヽ  ▩        +  Ä  ヽ  ▩  +  ヽ
C |       ,  <  L  \  └  ┘        é  Ö  └  ┘  é  └
D |       -  =  M  ]  ╱  ▩        £  Ü  ╱  ▩  £  ╱
E |       .  >  N  ↑  ▔  π        è  ß  ▔  π  è  ▔
F |       /  ?  O  —  ⌐  _        '  ˆ  ⌐  _  '  π
```

Table : GERMANY Charset in Uppercase/Graphic Mode (Secondary address = 0)

```
   | 0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
---+------------------------------------------------
0 |          0  @  p  `  P           §  `  P     §
1 |       !  1  a  q  A  Q        |  à  A  Q  |  à
2 |       "  2  b  r  B  R        └  è  B  R  └  è
3 |       #  3  c  s  C  S        ┴  ì  C  S  ┴  ì
4 |       $  4  d  t  D  T        ┘  ò  D  T  ┘  ò
5 |       %  5  e  u  E  U        ├  ù  E  U  ├  ù
6 |       &  6  f  v  F  V        —  â  F  V  —  â
7 |       '  7  g  w  G  W        ┤  ê  G  W  ┤  ê
8 |       (  8  h  x  H  X        ┌  î  H  X  ┌  î
9 |       )  9  i  y  I  Y        ┬  ô  I  Y  ┬  ô
a |       *  :  j  z  J  Z        ┐  û  J  Z  ┐  û
b |       +  ;  k  [  K  Ä        +  ä  K  Ä  +  ä
c |       ,  <  l  \  L  Ö        é  ö  L  Ö  é  ö
d |       -  =  m  ]  M  Ü        £  ü  M  Ü  £  ü
e |       .  >  n  ↑  N  π        è  ß  N  π  è  ß
f |       /  ?  o  —  O  _        '  é  O  _  '  π
```

Table GERMANY Charset in Lowercase/Uppercase Mode (Secondary address = 7)

5.6.5 Spain

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0			0	@	P	`	⌐				←	`	⌐		←	
1			!	1	A	Q	◣	◤			|	À	◣	◤	|	À
2			"	2	B	R	▬	╱			└	È	▬	╱	└	È
3			#	3	C	S	▬	▪			┴	♠	▬	▪	┴	♠
4			$	4	D	T	▪	╲			┘	Ò	▪	╲	┘	Ò
5			%	5	E	U	▪	▮			├	♥	▪	▮	├	♥
6			&	6	F	V	╲	▬			─	Á	╲	▬	─	Á
7			'	7	G	W	╱	▪			┤	É	╱	▪	┤	É
8			(	8	H	X	▮	▬			┌	Í	▮	▬	┌	Í
9			)	9	I	Y	|	─			┬	Ó	|	─	┬	Ó
A			*	:	J	Z	|	▮			┐	Ú	|	▮	┐	Ú
B			+	;	K	[	╲	¡			+	Ï	╲	ë	+	Ï
C			,	<	L	\	└	¿			£	Ü	└	ï	£	Ü
D			–	=	M	]	╱	▪			'	Ñ	╱	°	'	Ñ
E			.	>	N	↑	─	π			♣	♦	─	π	♣	♦
F			/	?	O	—	┌	┘			¨	Ç	┌	ç	¨	π

Table : SPAIN Charset in Uppercase/Graphic Mode (Secondary address = 0)

	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
0			0	@	p	`	P				←	`	P		←	
1			!	1	a	q	A	Q			|	à	A	Q	|	à
2			"	2	b	r	B	R			└	è	B	R	└	è
3			#	3	c	s	C	S			┴	♠	C	S	┴	♠
4			$	4	d	t	D	T			┘	ò	D	T	┘	ò
5			%	5	e	u	E	U			├	♥	E	U	├	♥
6			&	6	f	v	F	V			─	á	F	V	─	á
7			'	7	g	w	G	W			┤	é	G	W	┤	é
8			(	8	h	x	H	X			┌	í	H	X	┌	í
9			)	9	i	y	I	Y			┬	ó	I	Y	┬	ó
a			*	:	j	z	J	Z			┐	ú	J	Z	┐	ú
b			+	;	k	[	K	¡			+	ï	K	¡	+	ï
c			,	<	l	\	L	¿			£	ü	L	¿	£	ü
d			–	=	m	]	M	Ñ			'	ñ	M	Ñ	'	ñ
e			.	>	n	↑	N	π			♣	♦	N	π	♣	♦
f			/	?	o	—	O	Ç			¨	ç	O	Ç	¨	π

Table SPAIN Charset in Lowercase/Uppercase Mode (Secondary address = 7)

5.6.6 Sweden

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0				0	@	P	—	⌐				⌐	—	⌐		⌐
1			!	1	A	Q	♠	●			▮	⊥	♠	●	▮	⊥
2			"	2	B	R	┃	—			▬	⊤	┃	—	▬	⊤
3			#	3	C	S	—	♥			—	┤	—	♥	—	┤
4			$	4	D	T	—	┃			_	┃	—	┃	_	┃
5			%	5	E	U	—	╱			┃	▮	—	╱	┃	▮
6			&	6	F	V	—	×			▩	▮	—	×	▩	▮
7			'	7	G	W	┃	○			┃	—	┃	○	┃	—
8			(	8	H	X	┃	♣			▨	—	┃	♣	▨	—
9			)	9	I	Y	╲	┃			◤	▬	╲	┃	◤	▬
A			*	:	J	Z	╲	♦			┃	┘	╲	♦	┃	┘
B			+	;	K	Ä	╱	+			├	▪	╱	+	├	▪
C			,	<	L	Ö	┗	▧			▪	▪	┗	▧	▪	▪
D			–	=	M	Å	╲	┃			┗	┘	╲	┃	┗	┘
E			.	>	N	↑	╱	π			⌐	▪	╱	π	⌐	▪
F			/	?	O	←	⌐	◣			▬	▪	⌐	◣	▬	π

Table : SWEDEN Charset in Uppercase/Graphic Mode (Secondary address = 0)

	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
0				0	@	p	—	P				⌐	—	P		⌐
1			!	1	a	q	A	Q			▮	⊥	A	Q	▮	⊥
2			"	2	b	r	B	R			▬	⊤	B	R	▬	⊤
3			#	3	c	s	C	S			—	┤	C	S	—	┤
4			$	4	d	t	D	T			_	┃	D	T	_	┃
5			%	5	e	u	E	U			┃	▮	E	U	┃	▮
6			&	6	f	v	F	V			▩	▮	F	V	▩	▮
7			'	7	g	w	G	W			┃	—	G	W	┃	—
8			(	8	h	x	H	X			▨	—	H	X	▨	—
9			)	9	i	y	I	Y			▨	▬	I	Y	▨	▬
a			*	:	j	z	J	Z			┃	✓	J	Z	┃	✓
b			+	;	k	ä	K	Ä			├	▪	K	Ä	├	▪
c			,	<	l	ö	L	Ö			▪	▪	L	Ö	▪	▪
d			–	=	m	å	M	Å			┗	┘	M	Å	┗	┘
e			.	>	n	↑	N	▨			⌐	▪	N	▨	⌐	▪
f			/	?	o	←	O	▨			▬	▪	O	▨	▬	▨

Table SWEDEN Charset in Lowercase/Uppercase Mode (Secondary address = 7)

5.6.7 Switzerland

```
   | 0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
---+---------------------------------------------------
0 |          0  @  P  `  ⌐              §  `  ⌐     §
1 |       !  1  A  Q  ◣  ◤        |  à  ◣  ◤  |  à
2 |       "  2  B  R  ▬  ⸜        └  è  ▬  ⸜  └  è
3 |       #  3  C  S  ▬  ▪        ⊥  ì  ▬  ▪  ⊥  ì
4 |       $  4  D  T  ▪  ⸝        ⅃  ò  ▪  ⸝  ⅃  ò
5 |       %  5  E  U  ▪  ▮        ⊢  ù  ▪  ▮  ⊢  ù
6 |       &  6  F  V  ╲  ▬        —  â  ╲  ▬  —  â
7 |       '  7  G  W  ╱  ▪        ⊣  ê  ╱  ▪  ⊣  ê
8 |       (  8  H  X  ▮  ▬        ⌐  î  ▮  ▬  ⌐  î
9 |       )  9  I  Y  |  _        ⊤  ô  |  _  ⊤  ô
A |       *  :  J  Z  |  ▮        ⌐  û  |  ▮  ⌐  û
B |       +  ;  K  [  ╲  ë        +  Ä  ╲  ë  +  Ä
C |       ,  <  L  \  └  ï        £  Ö  └  ï  £  Ö
D |       -  =  M  ]  ╱  ²        '  Ü  ╱  ²  '  Ü
E |       .  >  N  ↑  ▔  π        ^  ß  ▔  π  ^  ß
F |       /  ?  O  —  ⌐  ç        ¨  é  ⌐  ç  ¨  π
```

Table : SWITZERLAND Charset in Uppercase/Graphic Mode (Secondary address = 0)

```
   | 0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
---+---------------------------------------------------
0 |          0  @  p  `  P              §  `  P     §
1 |       !  1  a  q  A  Q        |  à  A  Q  |  à
2 |       "  2  b  r  B  R        └  è  B  R  └  è
3 |       #  3  c  s  C  S        ⊥  ì  C  S  ⊥  ì
4 |       $  4  d  t  D  T        ⅃  ò  D  T  ⅃  ò
5 |       %  5  e  u  E  U        ⊢  ù  E  U  ⊢  ù
6 |       &  6  f  v  F  V        —  â  F  V  —  â
7 |       '  7  g  w  G  W        ⊣  ê  G  W  ⊣  ê
8 |       (  8  h  x  H  X        ⌐  î  H  X  ⌐  î
9 |       )  9  i  y  I  Y        ⊤  ô  I  Y  ⊤  ô
a |       *  :  j  z  J  Z        ⌐  û  J  Z  ⌐  û
b |       +  ;  k  [  K  ë        +  ä  K  ë  +  ä
c |       ,  <  l  \  L  ï        £  ö  L  ï  £  ö
d |       -  =  m  ]  M  ²        '  ü  M  ²  '  ü
e |       .  >  n  ↑  N  π        ^  ß  N  π  ^  ß
f |       /  ?  o  —  O  ç        ¨  é  O  ç  ¨  π
```

Table SWITZERLAND Charset in Lowercase/Uppercase Mode (Secondary address = 7)

5.7 EPSON FX-80 character table

5.7.1 Basic charset

```
      0 1 2 3 4 5 6 7 8 9 A B C D E F

0         0 @ P ` p       0 @ P ` p
1       ! 1 A Q a q     / 1 A Q a q
2       " 2 B R b r     " 2 B R b r
3       # 3 C S c s     # 3 C S c s
4       $ 4 D T d t     * 4 D T d t
5       % 5 E U e u     % 5 E U e u
6       & 6 F V f v     & 6 F V f v
7       ' 7 G W g w     ' 7 G W g w
8       ( 8 H X h x     ( 8 H X h x
9       ) 9 I Y i y     ) 9 I Y i y
A       * : J Z j z     * : J Z j z
B       + ; K [ k {     + ; K [ k {
C       , < L \ l |     , < L \ l |
D       - = M ] m }     - = M ] m }
E       . > N ^ n ~     . > N ^ n ~
F       / ? O _ o       / ? O _ o
```

5.7.2 Extended charset

```
      0 1 2 3 4 5 6 7 8 9 A B C D E F

0   à §   0 @ P ` p à §   0 @ P ` p
1   è ß ! 1 A Q a q è ß / 1 A Q a q
2   ù   " 2 B R b r ù   " 2 B R b r
3   ò   # 3 C S c s ò   # 3 C S c s
4   ì   $ 4 D T d t ì   * 4 D T d t
5   ° ø % 5 E U e u ° Ø % 5 E U e u
6   £ ¨ & 6 F V f v £ ¨ & 6 F V f v
7     Ä ' 7 G W g w   Ä ' 7 G W g w
8     Ö ( 8 H X h x   Ö ( 8 H X h x
9     Ü ) 9 I Y i y   Ü ) 9 I Y i y
A     ä * : J Z j z   ä * : J Z j z
B       + ; K [ k {     + ; K [ k {
C     ü , < L \ l |   ü , < L \ l |
D     É - = M ] m }   É - = M ] m }
E     é . > N ^ n ~   é . > N ^ n ~
F     ¥ / ? O _ o     ¥ / ? O _ o Ø
```

5.7.3 International charsets changes

```
CHARSET      23h 24h 40h 5Bh 5ch 5dh 5eh 60h 7Bh 7Ch 7Dh 7Eh

Basic         #   $   ə   [   \   ]   ^   `   {   |   }   ~
USA           #   $   ə   [   \   ]   ‥   `   {   |   }   ~
France        #   $   à   °   ç   §   ^   `   é   ù   è   ‥
Germany       #   $   §   Ä   Ö   Ü   ^   `   ä   ö   å   ü
UK            £   $   ə   [   \   ]   ^   `   {   |   }   ~
Denmark I     #   $   ə   Æ   Ø   Å   ^   `   æ   ø   å   ~
Sweden        #   ¤   É   Ä   Ö   Å   Ü   é   ä   ö   å   ü
Italy         #   $   ə   °   \   é   ^   ù   à   ò   è   ì
Spain         ₧   $   ə   ¡   Ñ   ¿   ^   `   ‥   ñ   }   ~
Japan         #   $   ə   [   ¥   ]   ^   `   {   |   }   ~
Norway        #   ¤   É   Æ   Ø   Å   Ü   é   æ   ø   å   ü
Denmark II    #   $   É   Æ   Ø   Å   Ü   é   æ   ø   å   ü
```

5.8 IBM character tables

5.8.1 Table 1

```
    0 1 2 3 4 5 6 7 8 9 A B C D E F

0       0 @ P ` p         á ▓ └ ⊥ α ≡
1     ! 1 A Q a q         í ▒ ┴ ╤ β ±
2     " 2 B R b r         ó ▓ │ Ⅱ Γ ≥
3     # 3 C S c s         ú │ ┬ Ⅱ π ≤
4     $ 4 D T d t         ñ ┤ ─ ╞ Σ ∫
5     % 5 E U e u         Ñ ╡ ┼ ╟ σ ∫
6     & 6 F V f v         ª ╢ ╞ ╠ μ ÷
7     ' 7 G W g w         º ╖ ╞ ╬ τ ≈
8     ( 8 H X h x         ¿ ╕ ╚ ╧ Φ °
9     ) 9 I Y i y         ⌐ ╣ ╔ ╨ Θ ∙
A     * : J Z j z         ¬ ║ ╩ ╥ Ω ·
B     + ; K [ k {         ½ ╗ ╦ █ δ √
C     , < L \ l |         ¼ ╝ ╠ █ ∞ ⁿ
D     - = M ] m }         ¡ ╜ ═ █ ø ²
E     . > N ^ n ~         « ╛ ╬ █ ∈ ■
F     / ? O _ o           » ┐ ╧ █ ∩
```

5.8.2 Table 2

International 1

```
     0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
0              0  @  P  `  p  Ç  É  á  ▓  └  ⊥  α  ≡
1           !  1  A  Q  a  q  ü  æ  í  ▓  ┴  ╤  β  ±
2           "  2  B  R  b  r  é  Æ  ó  ▓  ┬  Ⅱ  Γ  ≥
3     ♥     #  3  C  S  c  s  â  ô  ú  ├  Ⅱ  π  ≤
4     ♦     $  4  D  T  d  t  ä  ö  ñ  ─  ⊢  Σ  ⌠
5     ♣  §  %  5  E  U  e  u  à  ò  Ñ  ┤  ┼  F  σ  ⌡
6     ♠     &  6  F  V  f  v  å  û  ª  ╢  ├  ┌  μ  ÷
7        '  7  G  W  g  w  ç  ù  º  ╖  ├  ╫  τ  ≈
8        (  8  H  X  h  x  ê  ÿ  ¿  ╕  ╚  ╪  Φ  °
9        )  9  I  Y  i  y  ë  Ö  ⌐  ╣  ╔  ┌  Θ  ·
A        *  :  J  Z  j  z  è  Ü  ¬  ║  ╠  ┌  Ω  ·
B        +  ;  K  [  k  (  ï  ¢  ½  ╗  ╬  ■  δ  √
C        ,  <  L  \  l  |  î  £  ¼  ╝  ╠  ∞  ⁿ
D        -  =  M  ]  m  )  ì  ¥  ¡  ╨  ═  ┌  ø  ²
E        .  >  N  ^  n  ~  Ä  ₧  «  ┘  ╫  ┃  ∈  ■
F        /  ?  O  _  o     Å  ƒ  »  ┐  ╧  ■  ∩
```

International 2

```
     0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
0              0  @  P  `  p  Ç  É  á  ▓  └  ⊥  α  ≡
1           !  1  A  Q  a  q  ü  æ  í  ▓  ┴  ╤  β  ±
2           "  2  B  R  b  r  é  Æ  ó  ▓  ┬  Ⅱ  Γ  ≥
3     ♥     #  3  C  S  c  s  â  ô  ú  ├  Ⅱ  π  ≤
4     ♦     $  4  D  T  d  t  ä  ö  ñ  ─  ⊢  Σ  ⌠
5     ♣  §  %  5  E  U  e  u  à  ò  Ñ  ┤  ┼  F  σ  ⌡
6     ♠     &  6  F  V  f  v  å  û  õ  ╢  ├  ┌  μ  ÷
7        '  7  G  W  g  w  ç  ù  õ  ╖  ├  ╫  τ  ≈
8        (  8  H  X  h  x  ê  ÿ  ¿  ╕  ╚  ╪  Φ  °
9        )  9  I  Y  i  y  ë  Ö  ã  ╣  ╔  ┌  Θ  ·
A        *  :  J  Z  j  z  è  Ü  Ã  ║  ╠  ┌  Ω  ·
B        +  ;  K  [  k  (  ï  ¢  õ  ╗  ╬  ■  δ  √
C        ,  <  L  \  l  |  î  £  h  ╝  ╠  ∞  ⁿ
D        -  =  M  ]  m  )  ì  Ø  ¡  ╨  ═  ┌  ø  ²
E        .  >  N  ^  n  ~  Ä  Ⱡ  ³  ┘  ╫  ┃  ∈  ■
F        /  ?  O  _  o     Å  ⱡ  ¤  ┐  ╧  ■  ∩
```

Israel

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0				0	@	P	`	p	א	)	á	▦	└	┴	α	≡
1			!	1	A	Q	a	q	ב	ס	í	▦	┴	╤	β	±
2			"	2	B	R	b	r	ג	ע	ó	▦	┬	Ⅱ	Γ	≥
3	♥		#	3	C	S	c	s	ד	ף	ú	▦	├	Ⅱ	π	≤
4	♦		$	4	D	T	d	t	ה	פ	ñ	┤	─	┕	Σ	⌠
5	♣	§	%	5	E	U	e	u	ו	ץ	Ñ	╡	┼	╒	σ	⌡
6	♠		&	6	F	V	f	v	ז	צ	ª	╢	╞	╓	µ	÷
7			'	7	G	W	g	w	ח	ק	º	╖	╟	╫	τ	≈
8			(	8	H	X	h	x	ט	ר	¿	╕	╚	╪	Φ	°
9			)	9	I	Y	i	y	י	ש	⌐	╣	╔	┘	Θ	·
A			*	:	J	Z	j	z	ך	ת	¬	║	╩	┌	Ω	·
B			+	;	K	[	k	{	ל	¢	½	╗	╦	█	δ	√
C			,	<	L	\	l	|	ם	¥	¼	╝	╠	█	∞	ⁿ
D			-	=	M	]	m	}	מ	¥	¡	╜	═	█	ø	²
E			.	>	N	^	n	~	ן	₧	«	╛	╬	█	∈	■
F			/	?	O	_	o		נ	ƒ	»	┐	╧	█	∩	

Greece

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0				0	@	P	`	p	Α	Ρ	ι	▦	└	┴	ω	Ω
1			!	1	A	Q	a	q	Β	Σ	κ	▦	┴	╤	ά	±
2			"	2	B	R	b	r	Γ	Τ	λ	▦	┬	Ⅱ	έ	≥
3	♥		#	3	C	S	c	s	Δ	Υ	µ	▦	├	Ⅱ	ή	≤
4	♦		$	4	D	T	d	t	E	Φ	ν	┤	─	┕	ï	⌠
5	♣	§	%	5	E	U	e	u	Z	X	ξ	╡	┼	╒	(	⌡
6	♠		&	6	F	V	f	v	H	Ψ	o	╢	╞	╓	ό	÷
7			'	7	G	W	g	w	Θ	Ω	π	╖	╟	╫	ύ	≈
8			(	8	H	X	h	x	I	α	ρ	╕	╚	╪	ü	°
9			)	9	I	Y	i	y	K	β	σ	╣	╔	┘	ώ	£
A			*	:	J	Z	j	z	Λ	γ	ς	║	╩	┌	Ά	·
B			+	;	K	[	k	{	M	δ	τ	╗	╦	█	Έ	√
C			,	<	L	\	l	|	N	ε	υ	╝	╠	█	Ή	ⁿ
D			-	=	M	]	m	}	Ξ	ζ	φ	╜	═	█	Ί	²
E			.	>	N	^	n	~	O	η	χ	╛	╬	█	Ό	■
F			/	?	O	_	o		Π	ϑ	ψ	┐	╧	█	Ύ	

Portugal

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0				0	@	P	`	p	Ç	É	á	▓	└	┴	α	≡
1			!	1	A	Q	a	q	ü	æ	í	▓	┴	╤	β	±
2			"	2	B	R	b	r	é	Æ	ó	▓	┬	Ⅱ	Γ	≥
3	♥		#	3	C	S	c	s	â	ô	ú	┤	Ⅱ	π	≤
4	♦		$	4	D	T	d	t	ä	ö	ñ	┤	─	╘	Σ	∫
5	♣	§	%	5	E	U	e	u	à	ò	Ñ	┤	┼	╒	σ	∫
6	♠		&	6	F	V	f	v	å	û	ª	╢	╞	╓	μ	÷
7			'	7	G	W	g	w	ç	ù	º	╖	╟	╫	τ	≈
8			(	8	H	X	h	x	ê	ÿ	¿	╖	╚	╪	Φ	°
9			)	9	I	Y	i	y	ë	Ö	⌐	╣	╔	┘	Θ	·
A			*	:	J	Z	j	z	è	Ü	¬	║	╚	┌	Ω	·
B			+	;	K	[	k	{	ï	¢	½	╗	╦	■	δ	√
C			,	<	L	\	l	¦	î	£	¼	╝	╠	■	∞	ⁿ
D			-	=	M	]	m	}	ì	¥	¡	╜	═	■	ø	²
E			.	>	N	^	n	~	Ä	Ê	³	╛	╬	■	€	■
F			/	?	O	_	o		Å	ô	ó	┐	╧	■	∩	

Spain

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0				0	@	P	`	p	Ç	É	á	▓	└	┴	α	≡
1			!	1	A	Q	a	q	ü	í	í	▓	┴	╤	β	±
2			"	2	B	R	b	r	é	ó	ó	▓	┬	Ⅱ	Γ	≥
3	♥		#	3	C	S	c	s	â	ô	ú	┤	Ⅱ	π	≤
4	♦		$	4	D	T	d	t	ä	ö	ñ	┤	─	╘	Σ	∫
5	♣	§	%	5	E	U	e	u	à	ò	Ñ	┤	┼	╒	σ	∫
6	♠		&	6	F	V	f	v	Å	û	ª	╢	╞	╓	μ	÷
7			'	7	G	W	g	w	ç	ù	º	╖	╟	╫	τ	≈
8			(	8	H	X	h	x	ê	Á	¿	╖	╚	╪	Φ	°
9			)	9	I	Y	i	y	ë	Ö	⌐	╣	╔	┘	Θ	·
A			*	:	J	Z	j	z	è	Ü	¬	║	╚	┌	Ω	·
B			+	;	K	[	k	{	ï	ò	½	╗	╦	■	δ	√
C			,	<	L	\	l	¦	î	£	¼	╝	╠	■	∞	ⁿ
D			-	=	M	]	m	}	ì	ú	¡	╜	═	■	ø	²
E			.	>	N	^	n	~	Ä	₧	«	╛	╬	■	€	■
F			/	?	O	_	o		È	Ÿ	»	┐	╧	■	∩	

5.9 Technical Specifications

Output Type PNG file 2-bit depth (4 grey levels) with lossless compression using LodePNG written by Lode Vandevenne (http://lodev.org/lodepng/)

typical file size range is 30kB - 140kB

Page size 1984 x 2580

Printable area size 1920 x 2160 (80 PICA characters and 60 lines at 1/6")

Horizontal Resolution 240 dpi

Vertical Resolution 216 dpi

Physical ratio A4 (21cm x 29,7cm)

Character matrix 8V x 11H in draft mode
16V x 12H in NLQ mode

Print pitches Pica, 10 char/in, 80 char/line
Elite, 12 char/in, 96 char/line
Micro, 15 char/in, 120 char/line
Condensed, 17.1 char/in, 137 char/line
Pica Compressed, 20 char/in, 160 char/line
Elite Compressed, 24 char/in, 192 char/line
Micro Compressed, 30 char/in, 240 char/line

Printing styles Boldface
Double width
Superscript
Subscript
Double strike
Underlined
Italic
Reversed
Overlined

5.10 Print Sample

With Printer Ink Density set to Medium. Emulation is Commodore MPS.

MPS EMULATION PRINT TEST PAGE

DRAFT Simple	Under,Aggp	Bold	Super	sub	Rev
ITALIC Simple	*Under,Aggp*	*Bold*	Super	sub	Rev
NLQ Simple	Under,Aggp	Bold	super	sub	Rev

DRAFT Double	Under,Aggp	Bold	Super	sub	Rev
ITALIC Double	*Under,Aggp*	*Bold*	Super	sub	Rev
NLQ Double	Under,Aggp	Bold	super	sub	Rev

DRAFT Large	Under,Aggp	Bold	Super	sub	Rev
ITALIC Large	*Under,Aggp*	*Bold*	Super	sub	Rev
NLQ Large	**Under,Aggp**	**Bold**	super	sub	Rev

DRAFT Lg Db	Under,Aggp	Bold	Super	sub	Rev
ITALIC Lg Db	*Under,Aggp*	*Bold*	Super	sub	Rev
NLQ Lg Db	**Under,Aggp**	**Bold**	super	sub	Rev

PICA	Draft Regular	*Draft Italic*	Near Letter Quality
ELITE	Draft Regular	*Draft Italic*	Near Letter Quality
MICRO	Draft Regular	*Draft Italic*	Near Letter Quality
CONDENSED	Draft Regular	*Draft Italic*	Near Letter Quality
PICA COMPRESSED	Draft Regular	*Draft Italic*	Near Letter Quality
ELITE COMPRESSED	Draft Regular	*Draft Italic*	Near Letter Quality
MICRO COMPRESSED	Draft Regular	*Draft Italic*	Near Letter Quality

GRAPHIC BITMAP
Simple Bitmap

```
    **** COMMODORE 64 BASIC V2 ****
 64K RAM SYSTEM  38911 BASIC BYTES FREE
READY.
```

Repeated Bitmap

PETASCII code tables

UPPER/GRAPHIC   LOWER/UPPER

```
 |0 1 2 3 4 5 6 7 8 9 A B C D E F              |0 1 2 3 4 5 6 7 8 9 A B C D E F
-+                                            -+
0|    0 @ P — ⌐              ⌐ — ⌐   ⌐         0|    0 @ p — P              ⌐ — P   ⌐
1|  ! 1 A Q ♠ ●   ⊥ ♠ ● ⊥                      1|  ! 1 a q A Q   ⊥ A Q ⊥
2|  " 2 B R | —   ⊤ | — ⊤                      2|  " 2 b r B R   ⊤ B R ⊤
3|  # 3 C S — ♥   ┤ — ♥ ┤                      3|  # 3 c s C S   ┤ C S ┤
4|  $ 4 D T ⊤ |   | ⊤ | |                      4|  $ 4 d t D T   | D T |
5|  % 5 E U ⌐ ╱   | ⌐ ╱ |                      5|  % 5 e u E U   | E U |
6|  & 6 F V — ×   ■ — × ■                      6|  & 6 f v F V   ■ F V ■
7|  ' 7 G W | o   ⌐ | o |                      7|  ' 7 g w G W   ⌐ G W |
8|  ( 8 H X | ✚   ⌐ | ✚ ⌐                      8|  ( 8 h x H X   ⌐ H X ⌐
9|  ) 9 I Y ╲ |   ╱ ╲ | ╱                      9|  ) 9 i y I Y   ╱ I Y ╱
A|  * : J Z ╲ ◆   | ╲ ◆ |                      A|  * : j z J Z   | J Z |
B|  + ; K [ ╱ +   ├ ╱ + ├                      B|  + ; k [ K +   ├ K + ├
C|  , < L £ ⌐ ▓   • ⌐ ▓ •                      C|  , < l £ L ▓   • L ▓ •
D|  - = M ] ╲ |   ╲ ╲ | ╲                      D|  - = m ] M |   ╲ M | ╲
E|  . > N ↑ ╱ π   ⌐ ╱ π ⌐                      E|  . > n ↑ N ▨   ⌐ N ▨ ⌐
F|  / ? O ← ⌐ ▚   ⌐ ⌐ ▚ π                      F|  / ? o ← O ▨   ⌐ O ▨ ▨
```

5.11 Document Revisions

Revision	Date	Author	Description
1.0.0	May 27, 2016	René Garcia	Initial release
1.0.1	May 30, 2016	René Garcia	Corrected capabilities table and options BIT IMG SUB corrected Ink Density samples
1.1	February 18, 2018	René Garcia	Rename MPS Printer Emulation to Virtual Printer New feature: ASCII output format

Interview RetroMagazine

Interview with Gideon Zweijtzer, creator of the 1541 Ultimate series of expansion cartridges and the Commodore 64 FPGA-based motherboard Ultimate64 - July 2018

Hi, Gideon and thank you so much for accepting my invitation for an interview. All the readers and the editorial staff of RetroMagazine are very excited to have the opportunity to ask you some questions about your experience in designing one of the most (if not the most) famous cartridge/expansion for the C64: the 1541 Ultimate. During 2017, according to your web site, the final steps of the Ultimate64 design have been completed, so the long-awaited board has finally got into production and the first batches have been shipped to the final users earlier this year.

Most of the Commodore 64 fans out there are well-aware of your fantastic products, but I'm pretty sure they don't know how it all began. So let's start from the beginning.

Can you please shortly introduce yourself and tell us something about your own story (ie. where you are born, growing up, your education, your personal interests, etc.)?

Hi David, thanks for the invitation! Talking about myself? Sure... I was born in Amsterdam in 1974, in a quite stable family with one older brother. I have always been interested in technicalities. Before the home computers came, I was always with my technical Lego, although I also loved to race around on my bike through the neighborhood. I often played with circuits made from switches, motors and light bulbs, but unfortunately I did not have anyone in my surroundings with knowledge of electronics. From the secondary school, I went to the university TU Delft, where I studied Electronic Engineering.

I guess you have always been a computer fan and user since when you were a kid. What started you on the path of computing and what was your first experience with a computer? Was the Commodore 64 your fist computer?

I was pretty young when we got an Atari 2600 game console. It was actually my brother who had started with the whole computer thing and he started to investigate the possibilities for programming. There was a basic interpreter for the A2600 at that time, but in the end he bought a ZX81. I was not really allowed to touch it, but sometimes I sneaked into his room and tried a few things, but as a kid without any help, I didn't get that far. Later, my brother got a Commodore 64 and this got big. It was so popular in that time! Computer clubs, meetings, copying games and programs! My brother infected me with his curiosity about programming and although he didn't want me to bother him, I could sit on the floor in between his massive desk and the old color TV that was on top of another table in front of that. As long as he didn't hear me, I could just watch what he was doing. I saw basic, assembler, etc. At a certain point I could tell him from behind the desk that he forgot a statement... It was not until I reached the age of 11 that I got my own Commodore 64.

How did you get started working on a C64, beyond playing games? Did you quickly find interest in programming and discovering how the machine intimately work?

I never really played a lot of games, actually. There are some exceptions, like Giana Sisters. But in general, I did not spend a lot of time on games altogether. As my brother focused a lot on the software, my interest in the hardware grew. At a certain point I made a simple thermometer, using an NTC thermistor on the paddle port of the C64. I needed my older brother again for his math skills to figure out the conversion curve. At the computer club in Amsterdam, I usually spent my time around the repair stand, where I could see how some guys were de-soldering and replacing chips in broken C64's. According to my mother, I had the full schematic of the C64 hanging from the wall in my small bedroom. But in all honesty, I don't remember that.

After the C64, did you get your first PC and still keep the C64 on your desk? Did you ever use one of the many SD2IEC devices on the market before starting to design the 1541 Ultimate?

No, I haven't. In fact, I think you're now skipping quite a few years. My interest in the C64 faded as the Amiga 500 came, and later the PC. Actually my first PC was a Pentium 120 MHz, so you can imagine that I have resisted PCs for quite some time... The love for the C64 never really went away, I just never used it. Neither have I ever been part of a demo- or game coder group, or the "scene" in general... So there was basically never a need for an SD2IEC or any other C64 peripheral.

What inspired you to design the first version of the 1541 Ultimate and when did you start?

The first version of the 1541 Ultimate was made in 2007. It all started with some implementations of the 6502 as I was learning and getting more experience with FPGA design using VHDL. That was back in 2001 or so. There were a lot of things going on back then. For instance, Jeri Ellsworth was working on her C-One, which later became the DTV, if I am not mistaken. In any case, I had already done a lot of the C64 in FPGA at that time, but I didn't see the point of being a "me-too" player. So I thought I'd do the floppy drive instead. On one of the club meetings that we have in Maarssen, I demoed the very first prototype on a Xilinx Spartan 3 board. You needed a laptop or PC to download a floppy image over Ethernet into its memory, after which the board acted as a floppy drive. No menu, no other emulations, only the drive. Later, in a conversation with one of my colleagues at work, the idea arose to build it into a cartridge, such that the VIC could be used to display a user-interface. This idea crystalized in 2007.

Did you design the hardware and the software/firmware for the 1541 Ultimate all by yourself?

Yes, basically. There have been some important contributions from others over the years, though. But in essence, the hardware design, the FPGA design and the firmware design and framework are made by me.

What was your computer system setup that you used to develop and test the early project of the cartridge?

Just a PC and one Commodore 64... And yes, that did not include a 1541 drive! Later it showed that this was not enough, but I did not have more hardware, so I visited some friends from the Commodore club that had impressive collections of machines to test the compatibility with. In fact, there I found out that the very first prototype of the 1541 Ultimate as a cartridge was not very compatible, which caused some design changes before the board went into production.

Did you take any computer courses to start you in the field of electronics? And if so, what were they and how much time did you invest? Or, like many designers/programmers of the early Eighties, were you a self-taught techie?

Many things were self-taught, although studying at Delft University of Technology has made me understand many more things. But to be fair, I think that I learned most at the job after my studies. I started to work as a junior designer at Technolution B.V., and there I learned most of the practical knowledge that I have today, in terms of electronics design. Interestingly, I brought knowledge about FPGA design back as I was one of the founders of this discipline within the company.

What was your development process like? Did you use to sketch out concepts, design the mainboard and the firmware, etc.? Do you still take on the design process the same way?

Oww, that's quite a difficult question. Because I have always seen these activities as a hobby, I mostly just let it happen. I am the kind of designer that does a lot of design work 'as a background process'. I am not a very structured,

method-following, step-by-step kind of engineer. (I made quite a few project-managers pull their hairs out, as they didn't see me work on new tasks they assigned to me in the first weeks. . .)

I work with iterations, basically. But mostly just in my mind. Sometimes under the shower, or while driving. Once it 'feels right', I start to do some implementation. And sometimes after an implementation I realize it doesn't feel as right anymore. I am not afraid of just throwing some work away and start anew. Of course, always taking into account the lessons learned in the previous step.

Talking about your biggest projects (the 1541 Ultimate cartridge and the new Ultimate64 mainboard), what technical challenge gave you the biggest feeling of accomplishment?

Ok, when I need to limit it to 'technical challenges', it would definitely be the solving of very hard-to-find bugs. . . You know, those nasty ones that make others quit on their project. . . Those! On a second place, it is when I power up a new board and everything works right away. (And that's not uncommon in my case. . . [smug face]).

What was the biggest tech/programming obstacle that you ever overcome while designing/producing/testing/selling the 1541 Ultimate or the Ultimate64?

Obstacles. . . [thinking]. . . It depends a bit on how you define the obstacles. Most things are just time consuming tasks. But yet, I think there are several 'obstacles'. I think in case of the 1541 Ultimate, it must have been creating an easy to use user interface without having access to any framework; building everything from scratch. On an embedded platform, which the Ultimate clearly is, you can't use standard frameworks like the ones commonly used in Java and C#, so you have to make one of your own.

Hmm, another obstacle was the development of a factory test system for the Ultimate-II+. That took quite some time. But then, I do think it saves me a lot of time.

Another one was the move to a web-shop system, rather than just taking orders and processing them manually.

What was/is your favorite game for the C64? Do you still find some time to play?

Giana Sisters. . . err.. no time to play!

I imagine that you do own a collection of stock C64s (i.e. all versions: from C64 "breadbin" with all the ASSY board revisions, to C64c, C64g and C128) for testing purpose. Are you a collectionist of retrocomputers as well, not only Commodore branded?

My wife would kill me, if I were actually collecting more. I only have working C64 mainboards, of which I use mainly just one in a C64C case. This has been the same machine as I used to test over 3000 ultimate's over the years. The power switch and cartridge port are a bit sad now. I do have a C128 and a C128D, but I never use them. I do have several floppy drives, too.

Can you even think about calculating how many hours you spent designing and working on the several versions of the 1541 Ultimate cartridge? What about the Ultimate64?

It is very difficult. As I said, many design activities take place as a background task. If I would count only the hours that I spend on the PC it might give a falsely low figure. What I can tell, tho, is that hardware designs, board layouts and such, usually don't take that much time. I think I created the U64 board design in about 3 weeks' time, but then of course only in the evenings and weekends. The schematics took a similar amount of time. Most time spent on technicalities goes into FPGA design, implementation and debug and firmware implementation.

From your question I sense that you focus a lot on the technical aspects, but I can tell you that the administrative tasks, including shipping orders and answering e-mails takes up most of my time, unfortunately.

Have you ever worked or are you planning to work on other projects involving the C64 or even different 8/16-bit machines?

Nope. . . :-)

How many people currently work at Gideon Lab on producing, testing and selling the two main products? Did you ever work in a team or simply get consulted with other electronics/software experts in order to achieve a particular result or to solve a bug?

Production is outsourced to a number of companies. (Production-) testing of the Ultimate-II+ is also performed in the factory. Production test for the U64 doesn't exist yet as of today, but that will be the next step in order to accelerate the process. When we talk about assembling the U2+ into plastic cases, that's often done by my wife, ... when she feels like it. She also plays an important role in packing orders. The other things are done by me; there are no employees at this point. Whether this can continue like this, is questionable. I think I do need external help for the quantity of U64's that are currently on order.

On the technical aspect, I sometimes talk with my colleagues about certain bugs, and of course I use the feedback and input from the community. There are some pretty smart guys out there that help me solve bugs sometimes. In order to achieve a particular result, I often apply patterns that I quietly pick up or learn from other projects.

Looking back to where you started it all, is there something that you regret about the PCB design or any other detail? Would you do something in a different way now if you could?

I mostly regret not taking the C64 FPGA code that I had made years before the U64 to a production level. I actually demoed a complete C64 in FPGA already back in 2011. I thought nobody would be interested in buying an FPGA-based C64 motherboard, since original C64 machines could be picked up for almost nothing, or else people would use an emulator anyway.

Regrets about other aspects: well, in retrospect many things could be regretted. But I think it is not fair to look at things like that, because as a person and as an engineer, you learn while you do it. Once you think things have to change, there is always the freedom to do so. I think that is one of the very cool things about having your own product. But I guess this principle applies to many things in life, doesn't it..?

I'm pretty sure that you worked very hard on both your projects during the last few years but also that you had so much fun doing it. What is the most funny/weird moment or story that you've been through while developing your products?

Oh, I absolutely had much fun doing it! Technically speaking, I have the most fun doing the FPGA code, second the hardware itself, and third the firmware.

I think one funny moment was the moment I realized how naive I can be. In the whole process of creating the 1541 Ultimate, I *never* thought of actually making a sellable product out of it. Or let's say, that was not my goal; it had always been pure hobby until then. It was actually a Swedish scener, TwoFlower, who happened to visit the Commodore Club in Maarssen just when I was giving the demo of a cartridge with an embedded floppy drive. He said I should have it produced, but I was hesitant and thought that it was not even feasible to do so. He asked me how many needed to be produced, and I stammered, "maybe 40 or 50?" He smiled and said: "Just do it... I'll make sure you'll sell all 40 of them in Sweden alone!" And that's how it all started!

Gideon, thank you very much for your time. This interesting interview ends here. Would you like to add anything, or say anything to our readers?

There is one important thing to mention.. I would like express a huge 'thank you' to the Commodore loving community. One of the most rewarding aspects of this project is the great feedback, the positive words I receive. In short: without you guys, I would never have been able to do all this. Thank you.

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