

---

# Ultimate Documentation

Mar 30, 2020



---

## Contents

---

|  |           |
|--|-----------|
| <b>1 Quick guide to the Ultimate-II+</b>                         | <b>1</b>  |
| <b>2 Ultimate-64 Documentation</b>                               | <b>9</b>  |
| <b>3 Modem support</b>   | <b>49</b> |
| <b>4 Command Interface</b>                                       | <b>53</b> |
| <b>5 Ultimate-II Virtual Printer</b>                             | <b>59</b> |
| <b>6 Interview RetroMagazine</b>                                 | <b>81</b> |
| <b>7 FAQ for the Ultimate II and Ultimate II Plus cartridges</b> | <b>85</b> |



---

## Quick guide to the Ultimate-II+

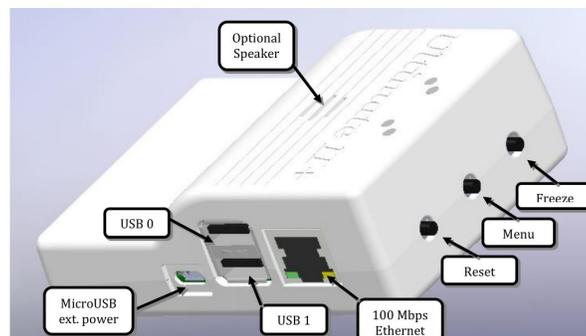
---

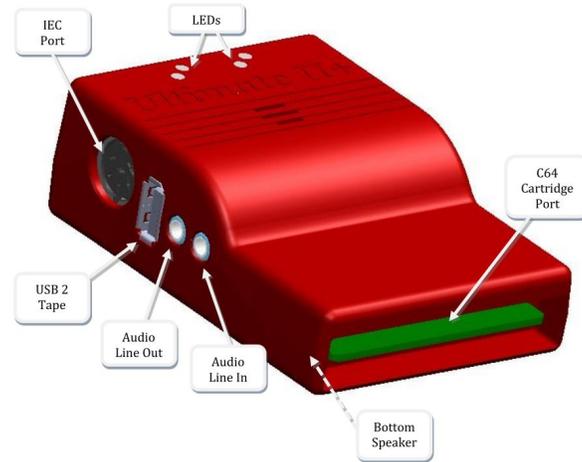
Thank you for purchasing the “Ultimate-II+” cartridge: The versatile storage solution for your Commodore 64 computer. Although the installation and use of the Ultimate-II+ are designed to be intuitive, this quick guide shows you the basic functions.

### 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 a 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<br>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.   |
| <i>Quick seek:</i> | 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:

- a. Green: 1541 drive power
- b. Red: 1541 drive status
- c. Yellow: Cartridge active
- d. 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<br>up/down       | Move the cursor (highlighted line) up/down  |
| CRSR<br>left/right    | Increase or decrease a setting, cycling through the available options.  |
| DEL                   | Go one level up   |
| Return /<br>Space     | For string fields: bring up a text entry box<br>For enumerated fields: bring up a context menu with the available options |
| Run-stop <sup>2</sup> | <i>Leaves</i> 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

---

<sup>2</sup> 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 Modem support

Starting from version 3.7, a lightweight modem emulation layer is provided in the firmware of the Ultimate. This modem layer is accessible through an emulated MOS 6551 ACIA chip. This chip was found in the SwiftLink cartridge, as well as some other ACIA based RS-232 cartridges of the time.

The modem emulation layer bridges the ACIA chip and the LAN port. The modem connects to a server (e.g. one that is running a bulletin board system) through the internet. In order to use this, the modem needs to be enabled in the configuration menu of the Ultimate application, as well as in the terminal program, e.g. CCGMS. The modem will respond to commands such as “ATDT”, which is followed by the domain name, followed by a colon and the port number. For example:

```
ATDTAFTERLIFE.DYNU.COM:6400
```

Incoming connections are also supported. This enables you to run a simple server on your C64, or maybe even a BBS!

## 1.11 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.

## 1.12 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.

## 1.13 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.

## 1.14 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.

## 1.15 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 may be used to mix external audio with the output of the Ultimate-II+ cartridge. The separate left and right inputs can be found in the Audio Mixer configuration menu.

### 1.15.1 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:

[https://github.com/GideonZ/1541ultimate/blob/master/doc/ultimate\\_audio\\_v0.2.pdf](https://github.com/GideonZ/1541ultimate/blob/master/doc/ultimate_audio_v0.2.pdf)

## 1.16 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.

## 1.17 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

### 1.17.1 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:

[https://github.com/GideonZ/1541ultimate/blob/master/doc/ultimate\\_printer.pdf](https://github.com/GideonZ/1541ultimate/blob/master/doc/ultimate_printer.pdf)

### 1.17.2 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.

## 1.18 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:

<https://github.com/GideonZ/1541ultimate/blob/master/doc/Command%20Interface%20V1.0.pdf>

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

[https://github.com/GideonZ/1541ultimate/blob/master/doc/ultimate\\_dos-1.2.pdf](https://github.com/GideonZ/1541ultimate/blob/master/doc/ultimate_dos-1.2.pdf)

## 1.19 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.

### 1.20 Social Media

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

### 1.21 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://ultimate64.com> 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.

### 1.22 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.

### 1.23 Known issues

- The processing speed of the Ultimate-II+ is currently (V3.7) 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 are reported and maintained on GitHub:

<https://github.com/GideonZ/1541ultimate/issues>

Welcome to the landing page of the Ultimate-64 documentation!

If you are unfamiliar to the Ultimate range of products, it is recommended to read the *Quick guide to the Ultimate-II+* first, which was written for the Ultimate-II+ cartridge. The application that manages the Ultimate-64 is in essence the same as the Ultimate-II+. Features and functions of this cartridge are also present in the Ultimate-64.

## 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

#### Commercially available kits

If you do not have a 3D printer yourself, you may also want to take a look at these kits that are available from Corei64 by Thomas Christoph, or the Pixelwizard Retro Shop from Thomas Koch. Both offer professional kits that make mounting of the U64 easy. Both shops have put special pages together, just for the U64, where the items are listed:

- All Ultimate64 accessories from Corei64
- All Ultimate64 accessories from Pixelwizard
- Installation kit for 64C Corei64
- Installation kit for 64C Pixelwizard
- Installation kit for breadbin Corei64
- New C64C cases in different colors Pixelwizard

Other installation accessories, stickers and batches are available at <https://www.corei64.com/shop/> or at <https://shop.pixelwizard.eu/en>

## 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.

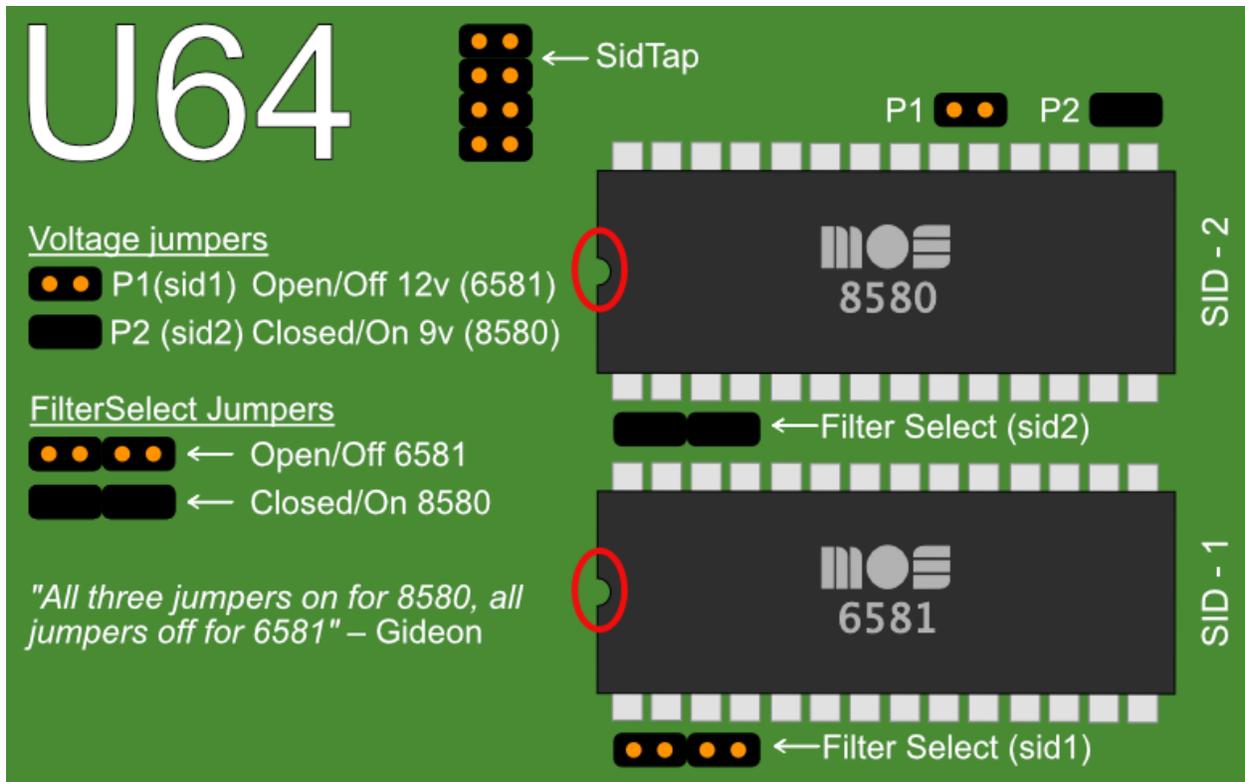
Basically you stick your USB drive in the back of the Ultimate 64 and push shortly on the power button to bring up the Menu.

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 on Board revisions 1.1, 1.2 and 1.2a

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
```

In Firmware revisions before V1.22, it is required 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.

## Real SID on Board revisions 1.3 (U64 Elite) and 1.4

The newer board revisions are jumperless. This means that both the voltage as well as the filter caps are selected automatically, based on the inserted SID type. For this, firmware V1.22 or later is *required*. *Do not downgrade to earlier versions on jumperless boards!*

In order to make sure that 8580 chips are never given a higher voltage than they can handle, the socket gets disabled automatically whenever an 6581 chip (which needs 12V) is detected for the first time. When the popup appears “SID changed”, enter the configuration menu, and enable the socket in which the 6581 resides:

```
Short press on power button
F2
SID Sockets Configuration
Enable the sockets with options:
SID in socket 1
and
SID in socket 2
```

Once the chip in the socket is recognized as 6581 AND the socket is enabled, the 12V is applied.

### Pull Down Resistor

Note that in the original schematics of the C64, a so called “pull-down” resistor of 1 k $\Omega$  is placed from the audio output pin to ground. This resistor is present on the 6581-based boards, but absent on the 8580-based boards. On the jumperless U64 boards this resistor is also enabled and disabled automatically. However, you may override this in the same configuration menu. The influence is limited.

## 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 overlaid 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<br>up/down    | Move the cursor (highlighted line) up/down  |
| CRSR<br>left/right | Increase or decrease a setting, cycling through the available options.  |
| DEL                | Go one level up   |
| Return /<br>Space  | For string fields: bring up a text entry box<br>For enumerated fields: bring up a context menu with the available options |
| Run-stop           | <i>Leave</i> 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.

```
*** Ultimate 64 V1.05 - 3.3 ***
-----
Usb0      SanDisk      Ready
Net0      MAC 02:15:41:C4:DC:84  Link Down

/                                               -F3=Help-
```

```
*** Ultimate 64 V1.05 - 3.3 ***
-----
g_i_joe      DIR
galaga      DIR
galax-i-birds  DIR
galaxian     DIR
galaxions   DIR
galivan     DIR
game over   DIR
```



## 2.3.3 F5 - Tool / Command menu

```

*** Ultimate 64 V1.05 - 3.3 ***
g_i_joe DIR
galag
galax Save EDID to file
galax Create D64
galax Create G64
galiv Flush Printer/Eject Page
game_ Reset IEC and Printer
games UltiCopy 8
games UltiCopy 9
gaplu Reset C64
garfi Reboot C64
garfi Power OFF
gary_ Save REU Memory
gary_ Create Directory
gates Sample tape to TAP
gatew Capture save to TAP
gaunt Reset 1541 Drive A
gaunt Insert blank disk in drive A
gazza_2 DIR
gazzas_super_soccer DIR
gba_championship_basketball DIR
/Usb0/c64 d64/G/ -F3=Help-

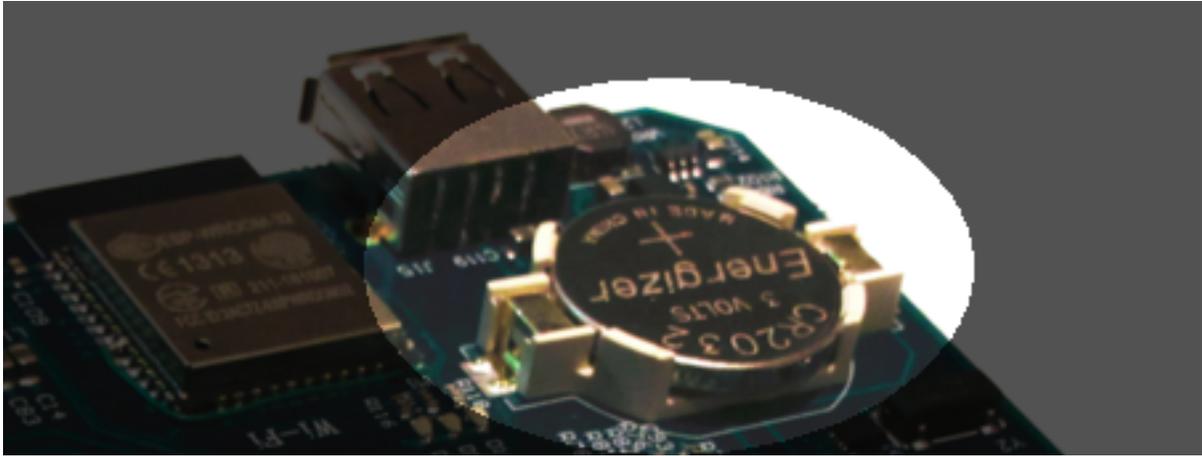
```

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 where 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 Configuration

### 2.4.1 Clock settings / RTC



The U64 has an internal clock that is powered with a battery to keep track of the date & time.

*See hardware RTC documentation*

At this config screen date & time can be changed with the following options:

- Year
- Month
- Day
- Hours
- Minutes
- Seconds
- **Correction**
  - This corrects the deviation of the internal clock (RTC)

### 2.4.2 Setting up the MultiSID configuration on the Ultimate 64

This page explains how to use the visual SID address editor to set the UltiSID in MultiSID mode, giving you four or even eight SIDs.

In the following example, it is assumed that the settings are as follows:

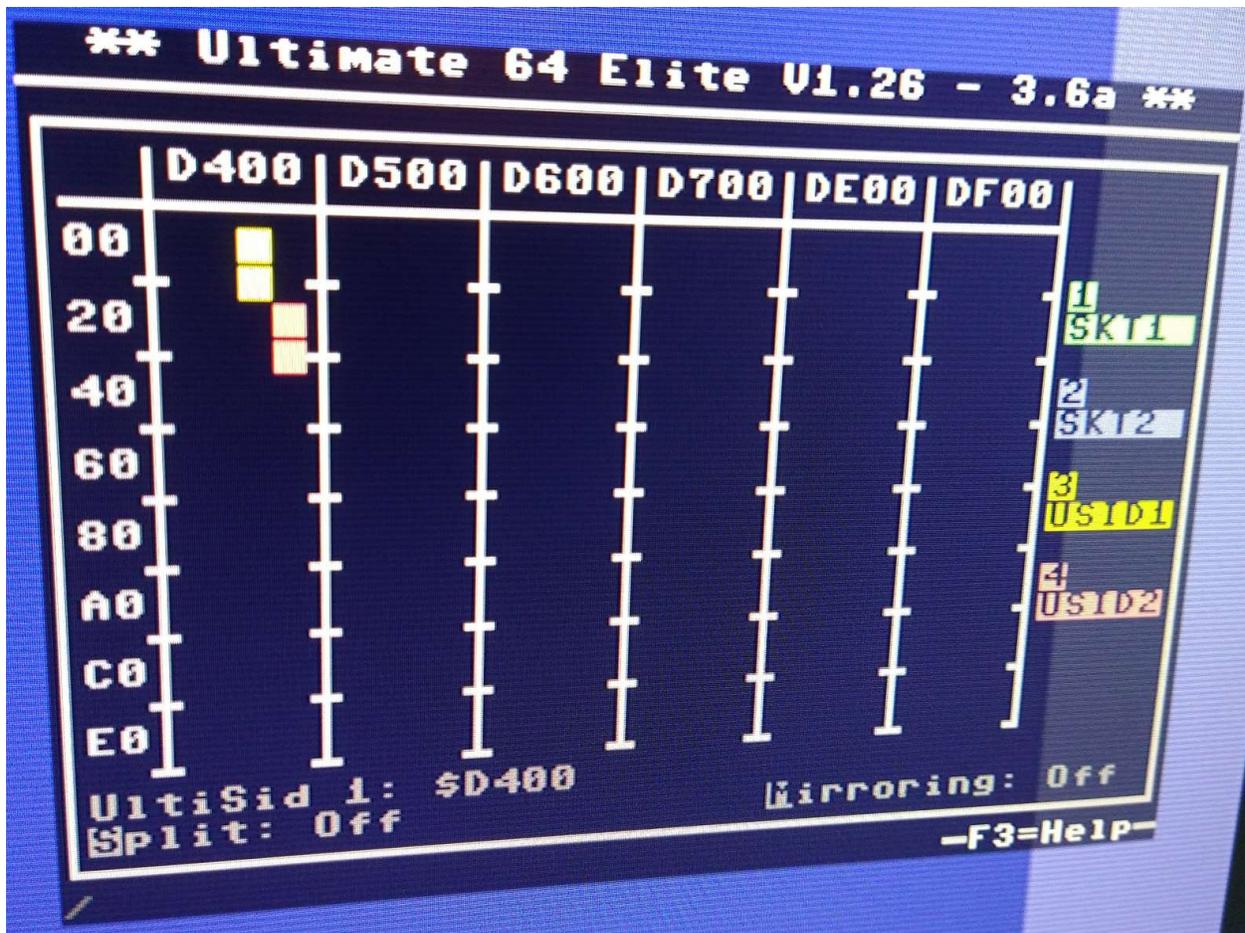
- SID Socket 1 Address: Unmapped
- SID Socket 2 Address: Unmapped
- UltiSID 1 Address: \$D400
- UltiSID 2 Address: \$D420
- UltiSID Range Split: Off
- Auto Address Mirroring: Enabled

First step is to enter the visual editor and note that UltiSID 1 is mapped at \$D400, UltiSID 2 is mapped at \$D420 and auto mirroring is on, just like the settings we started with. Address mirroring means that the appearance of the available SIDs are mirrored in the address space, such that they fill up the \$D400-\$D7FF range. Also pay attention that the lower line shows “Socket 1”, which means that the controls (cursor and split) now have effect on socket 1.

We want to change the UltiSID settings, so we press “3” on the keyboard; the highlighted number next to the “USID1” label.



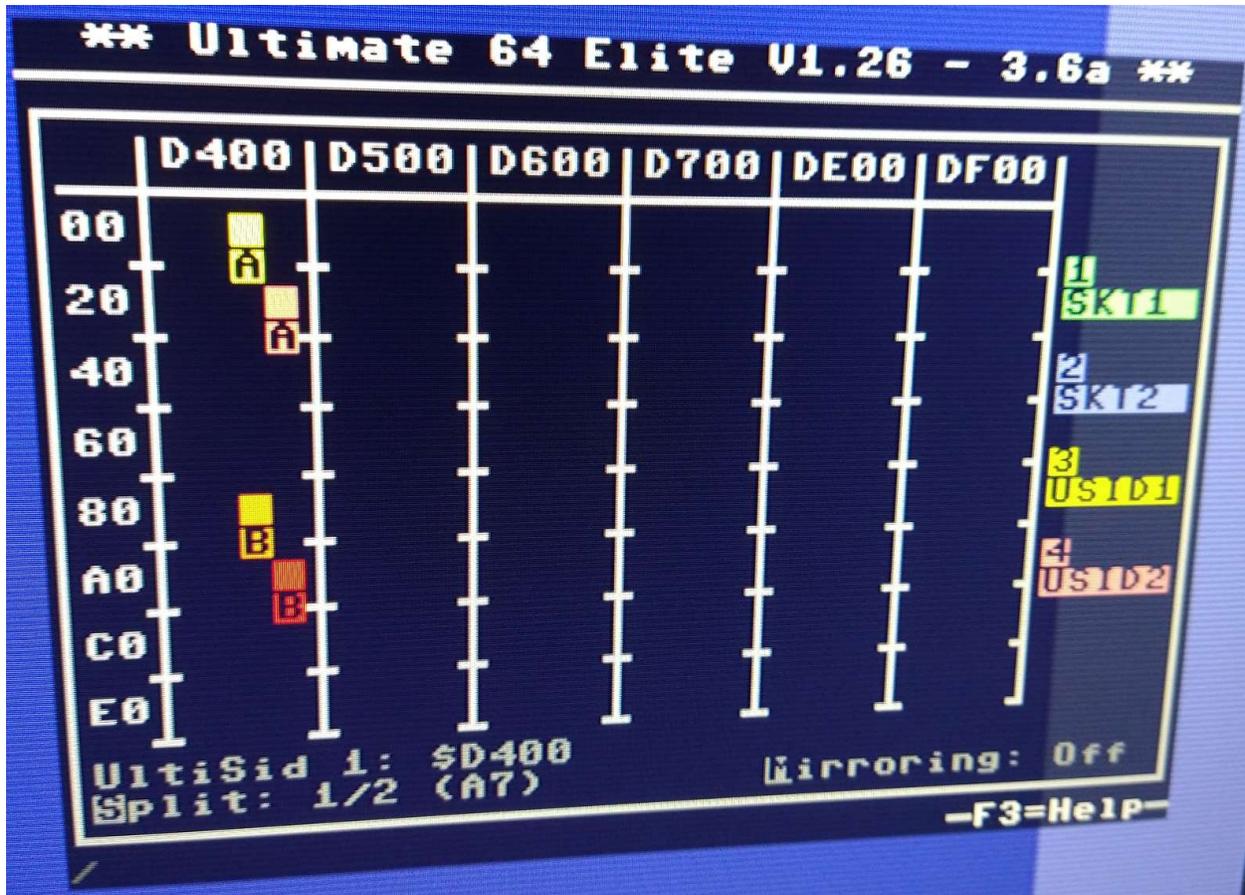
Press “M” to turn off auto mirroring, to have a better view of the settings. Note the lower line says “UltiSid 1”, which we will modify.



When pressing “S”, the split function gets enabled. The line below shows the split is active on one address line, being A6. This means the UltiSIDs (both of them) get split in two, and the second part of it gets enabled with address line 6 set (thus \$D440). Note that this instance gets a “B”, indicating the second half of the split UltiSID1. The same goes for UltiSID2, which now appears at \$D460.



Similarly for a split on A7; the second half appears with an offset of \$80.



And last but not least, split on two address lines, causing the UltiSID to be split into four SIDs. In this case A7 and A8, such that the second part appears at \$D480 (A7=1), the third part at \$D500 (A8=1), and the fourth part at \$D580 (A7=1, A8=1). Also note the letters A, B, C and D.



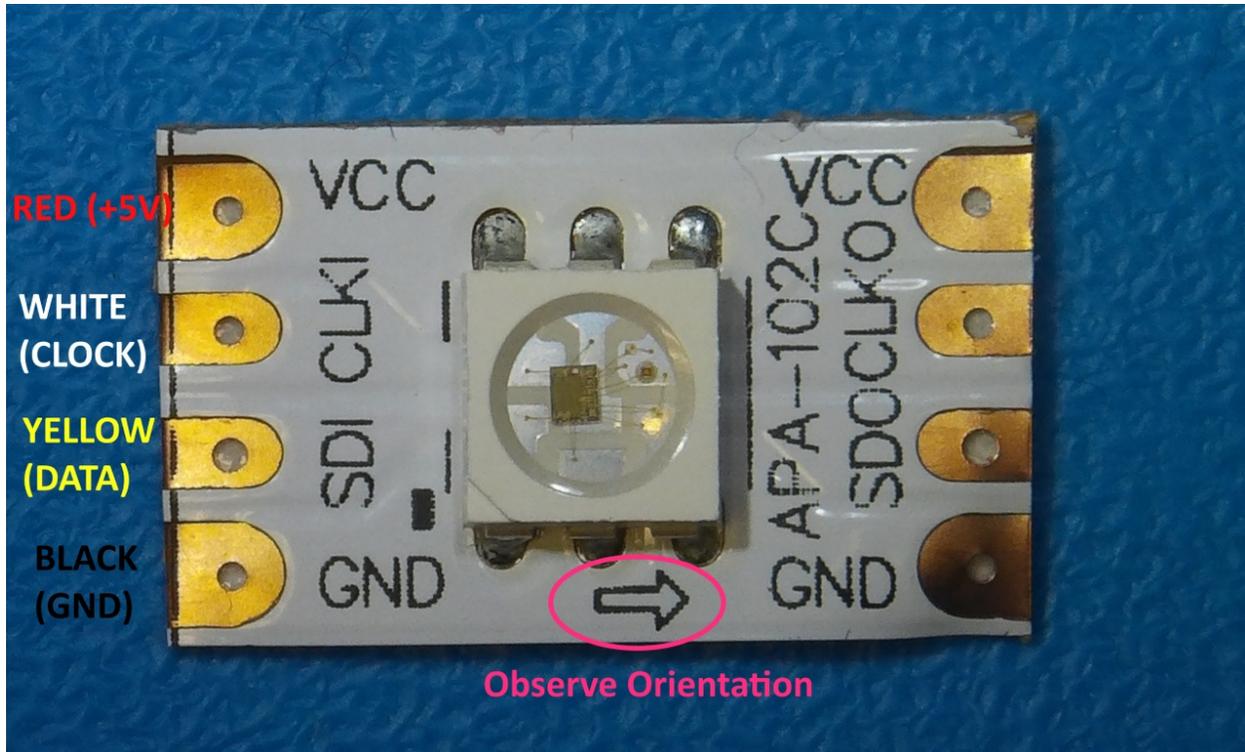
Since the split settings are shared for both UltiSIDs, UltiSID2 also gets split in the same way. But because its base address was set at \$D420 (A5=1), the splits appear also at offsets where A5=1, thus \$D420, \$D4A0, \$D520, \$D5A0. In total 8 SIDs, thus 24 voices and 8 independent filters.

## 2.5 Hardware

### 2.5.1 LED Strip

#### Attaching a LED Strip

Using [firmware version 1.10 and later](#), 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 (IP30) per meter, this corresponds to 40 cm of length, which is roughly the width of the machine. Alternative are SK9822 strips.



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*.

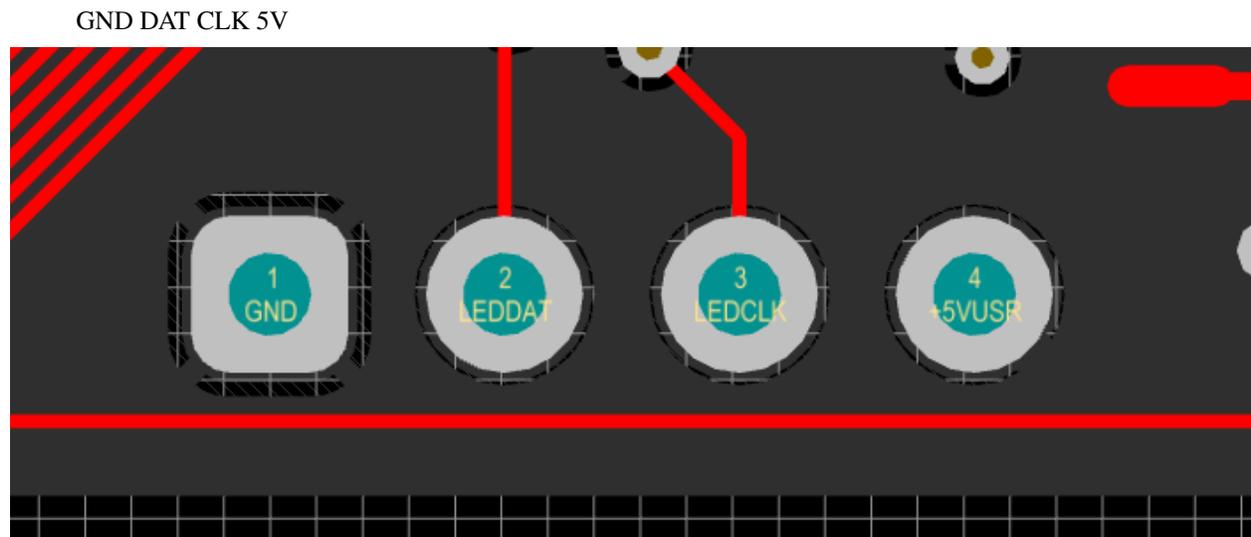
### LED pinheader P8

Beginning with hardware revision 1.4 you'll find the new LEDstrip pin header P8 to the left under the User Port. This can be used to attach an APA102C LED strip and simultaneously use the User Port for other purposes.

The pin header is defined as follows:

P8—————

**Pin: 1 2 3 4**



**W A R N I N G !** Please always use extreme caution!

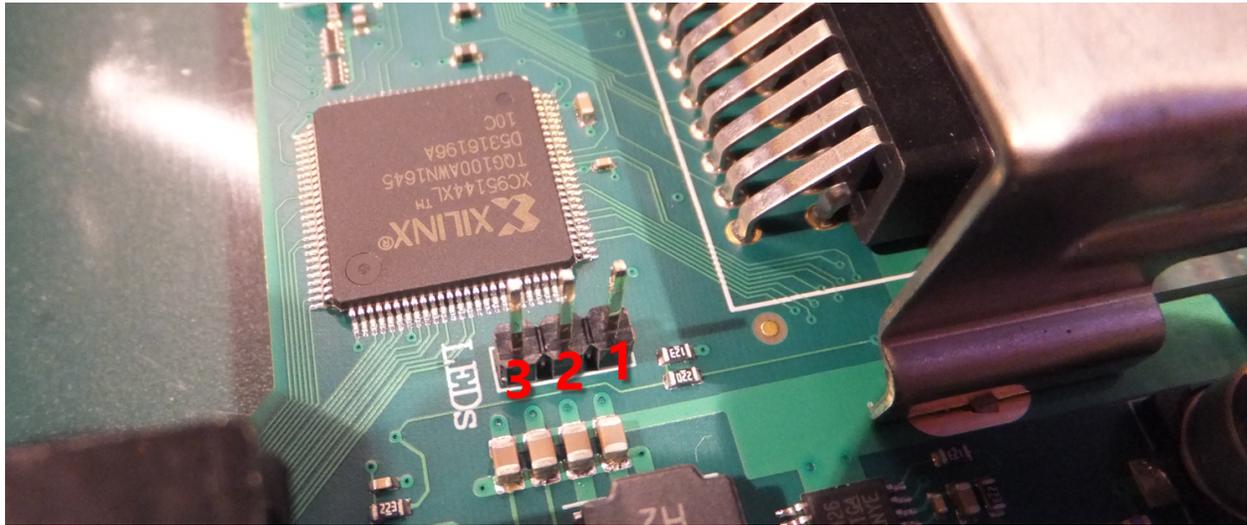
Please be extremely careful not to shorten the 5V to ground! It will burn a ferrite bead on your board! Also shorting 5V to pin 3 or any other FPGA pin will likely damage the FPGA!

## 2.5.2 LED Header

### Pinout

| Pin | Description    |
|-----|----------------|
| 1   | Power          |
| 2   | Ground         |
| 3   | Drive activity |

*With firmware 1.18 (and above) the pin assignment is not static any more.*



```

*** Ultimate 64 V1.18 - 3.4c ***
-----
Vol Socket 2                0 dB
Vol Sampler L                0 dB
Vol Sampler R                0 dB
Vol Drive 1
Vol Drive 2
Vol Tape Read
Vol Tape Write
Pan UltiSID 1
Pan UltiSID 2
Pan Socket 1
Pan Socket 2
Pan Sampler L
Pan Sampler R
Pan Drive 1
Pan Drive 2
Pan Tape Read
Pan Tape Write
LED Select Top
LED Select Bot
Speaker Volume (Sp

On
Off
Drive A Pwr
DrvAPwr + DrvBPwr
Drive A Act
DrvAAct + DrvBAct
DrvAPwr ^ DrvAAct
USB Activity
Any Activity
!(DrvAAct)
!(DrvAAct+DrvBAct)
!(USB Act)
!(Any Act)
IRQ Line
!(IRQ Line)

a--F3=Help--
    
```

## LED options

Table 1: LED Options

| Option             | Description   |
|--------------------|---|
| On                 | LED always ON   |
| Off                | LED always OFF  |
| Drive A Pwr        | Power indicator of drive A  |
| DrvAPwr + DrvBPwr  | Power indicator of drive A and drive B combined   |
| Drive A Act        | LED ON when there is activity on drive A  |
| DrvAAct + DrvBAct  | LED ON, on activity of drive A and B combined   |
| DrvAPwr ^ DrvAAct  | Drive power LED XOR drive activity. This results in an inverse drive activity, with similar dimming as the power LED has. |
| USB Activity       | LED ON, on USB activity   |
| Any Activity       | LED ON, on any activity (excluding tape)  |
| !(DrvAAct)         | Inverse of drive A activity, so the LED will turn OFF on drive activity instead of ON                                     |
| !(DrvAAct+DrvBAct) | Inverse of drive A and B combined, so LED will turn OFF on activity instead of ON   |
| !(USB Act)         | Inverse of USB Activity, so the LED will turn OFF on USB activity instead of ON   |
| !(Any Act)         | Inverse of Any Activity, so the LED will turn OFF on any activity instead of ON   |
| IRQ Line           | LED is ON when IRQ line is high (inactive)  |
| !(IRQ Line)        | Inverse of IRQ Line, so the LED is ON when IRQ line is low (active)   |

With the introduction of firmware 1.18 the behaviour of the LED can be changed.

### What does !(option) mean?

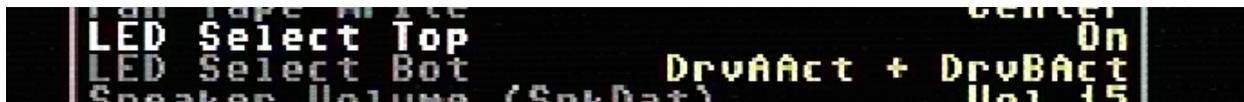
As we can see in the table above, there are setting options (functions) that are noted as !(function). !(function) means it is an inverse outcome of a function.

We take a closer look at the function **DrvAAct+DrvBAct**. This means when there is drive A or drive B activity (combined) the LED will turn ON. So **!(DrvAAct+DrvBAct)** will do the opposite (inverse) of the function **DrvAAct+DrvBAct**, so the LED will turn OFF when there is activity on drive A or drive B.

### Example with two separate LED's

We are using a red and green LED, red will be the power LED (power) and green will be drive activity (drive). The power wire to the red led is connected to the Top pin (1) and the green led is connected to the Bottom pin (3), and of course the ground of both LED's is connected to the ground pin (2).

Because there are two separate LED's we want that the power is always ON, and the drive will only turn ON when there is activity.



So we use the following setting:

- Power => LED Select Top: **On**
- Drive => LED Select Bottom: **DrvAAct+DrvBAct**

To swap the color assignment, just swap the settings between Top and Bottom.

### Example with duo LED

We are using a duo LED that has red and green combined in one package, red will be the power LED (power) and green will be drive activity (drive). The power wire to the red led is connected to the Top pin (1) and the green led is connected to the Bottom pin (3), and of course the ground of the LED is connected to the ground pin (2).

Because there is only “one” LED package we want that power will turn OFF when there is drive activity, or else the two colors will be mixed to yellow (red+green).



So we use the following setting:

- Power => LED Select Top: **!(DrvAAct+DrvBAct)**
- Drive => LED Select Bottom: **DrvAAct+DrvBAct**

To swap the color assignment, just swap the settings between Top and Bottom.

### Technical information

#### Power LED

The power pin is provided with a 260KHz PWM signal, the PWM signal makes the LED less bright. The U64 has an on-board 220 ohms series resistor to lower the current, the supplied voltage 3.3V.

#### Drive activity LED

| PWM | Description                               |
|-----|---|
| Off | Drive Off                                 |
| 1/3 | Drive On                                  |
| 2/3 | Drive On + Floppy Mounted                 |
| 3/3 | Drive On + Floppy Mounted + Motor running |

*PWM = pulse width of the pwm signal.*

### 2.5.3 Audio/Video Connector

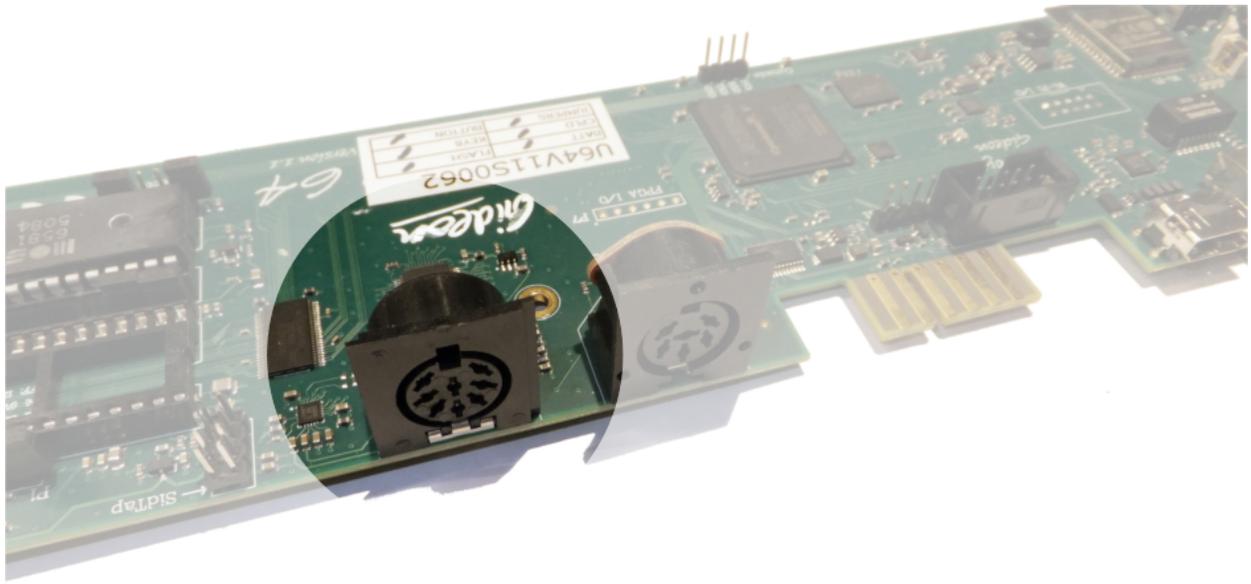
*Note:* The connector used is a full size 8-pin 262° DIN, also known as the ‘horse-shoe’ type. A 270° DIN plug does *NOT* fit without violence.

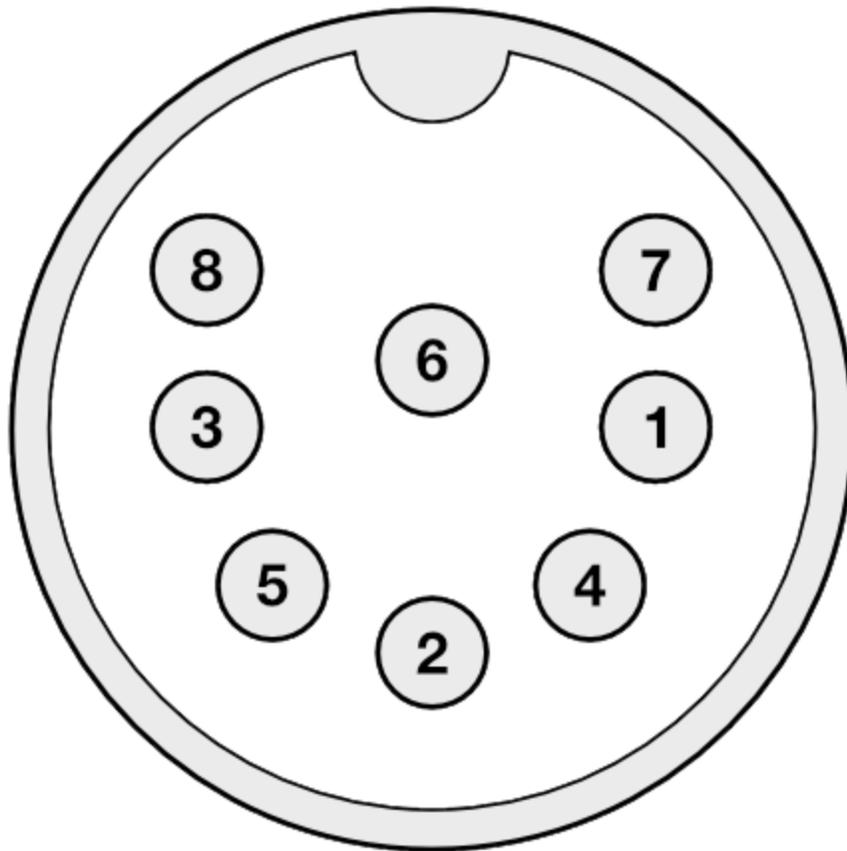
The 8-pin DIN (audio/video) connector can output several different video signals, for each type you need a special assembled cable.

#### 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.*





## 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  |

## Audio

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

## 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.

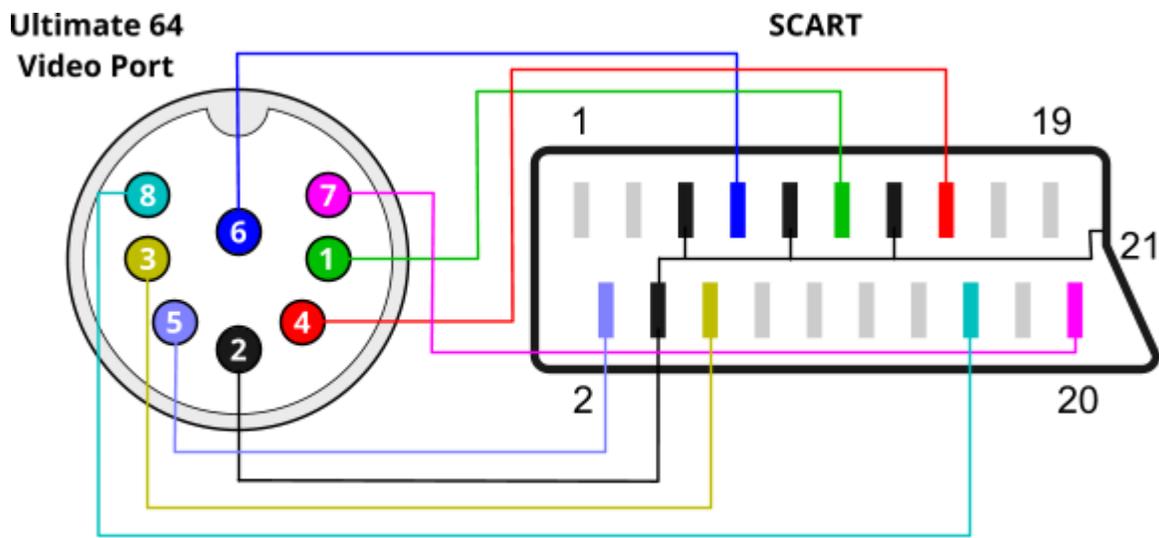
The PAL output is non-interlaced, with a field rate of 50.2 Hz, and line rate of 15.639 kHz.

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'.

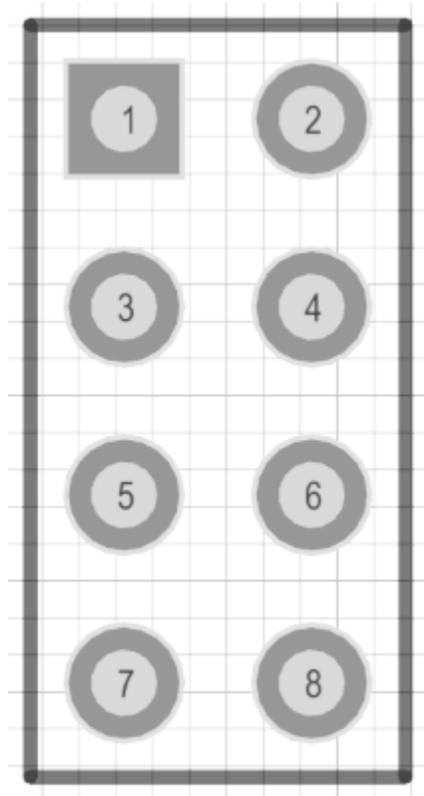
## Build your own RGB Scart cable

Pinout U64 & SCART

| Pin | U64 video port  | Pin | SCART                     |
|-----|-----------------|-----|---------------------------|
| 1   | Green           | 11  | RGB Green                 |
| 2   | Ground          | 4   | and pin 5,9,13, 21(Shell) |
| 3   | Audio Out Left  | 6   | Audio Input Left          |
| 4   | Red             | 15  | RGB Red                   |
| 5   | Audio Out Right | 2   | Audio Input Right         |
| 6   | Blue            | 7   | RGB Blue                  |
| 7   | Csync           | 20  | Composite video input     |
| 8   | Fast switching  | 16  | RGB Selection, 1-3V = RGB |



*\*Connectors shown in back view\**



### 2.5.4 SID-TAP header

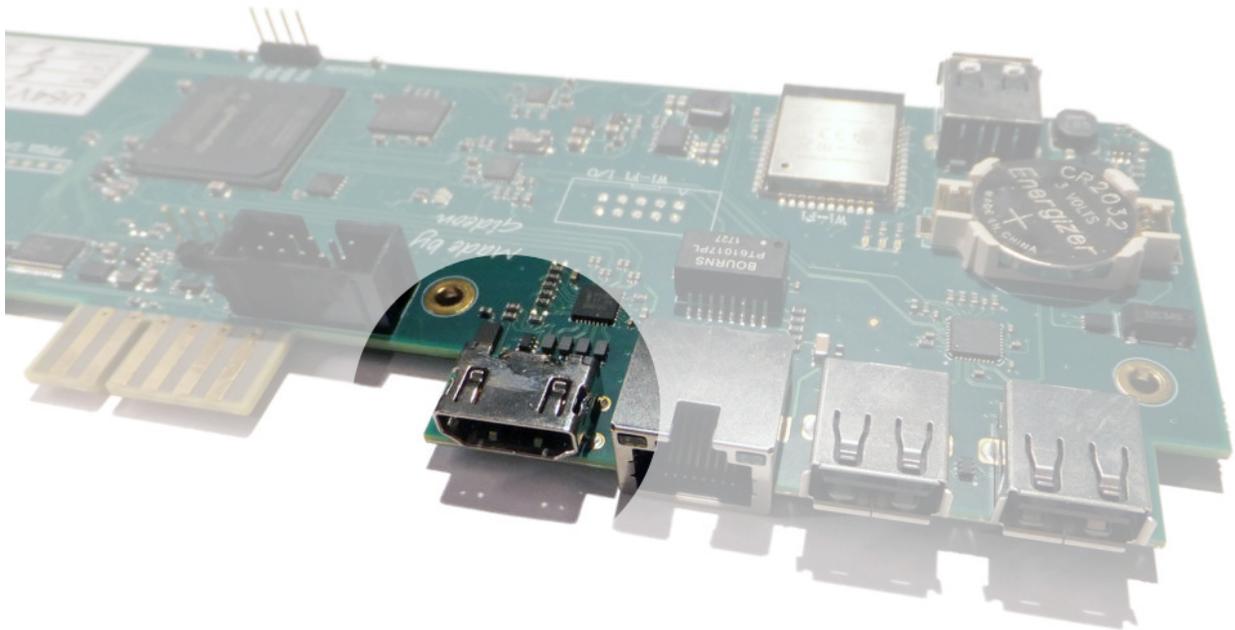
| Function  | Pin | Pin | Function |
|-----------|-----|-----|----------|
| SID 2 OUT | 1   | 2   | Ground   |
| Ground    | 3   | 4   | SID 2 IN |
| Ground    | 5   | 6   | SID 1 IN |
| SID 1 OUT | 7   | 8   | Ground   |

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.

### 2.5.5 HDMI port



The HDMI port can be connected to a modern display ( eg. television ), so you can use the Ultimate-64 in the future.

#### Resolution of the HDMI output

The output resolution is 720 x 576 at 50 Hz (for the PAL version), also noted as 576p50. This is a standard resolution that all HDMI capable screens are supposed to support, according to the CEA-861 standard. However, to meet the exact timing of a C64, the timing parameters of this video mode are slightly modified. I have not come across screens that do not accept the generated HDMI signal.

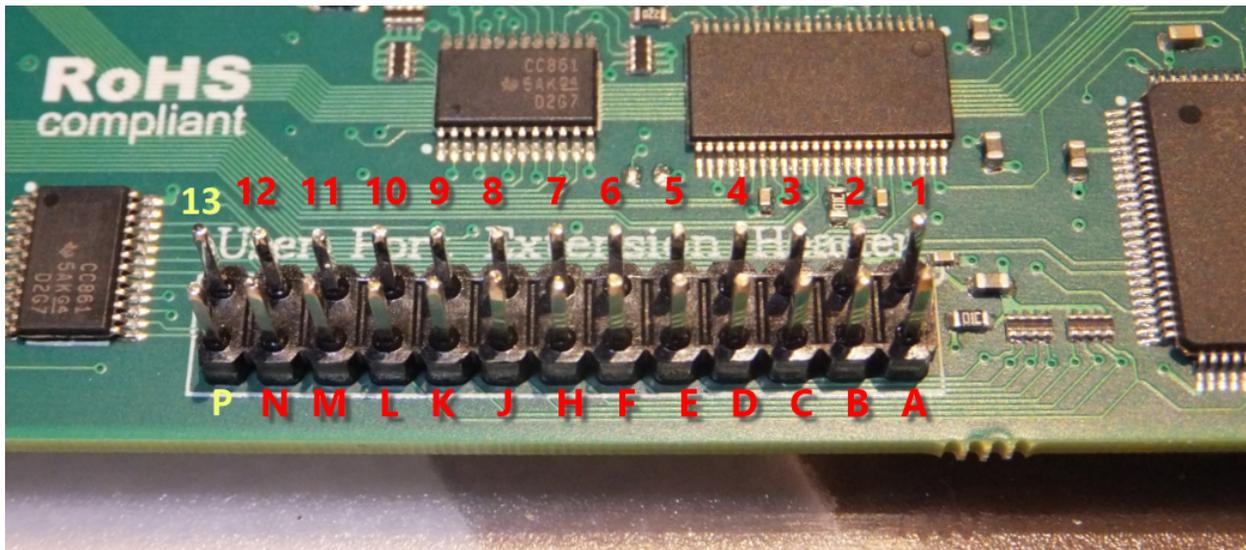
## Frame delays of the digital HDMI port

None. There is no frame buffer, so there is no need to worry. Some screens, tho, especially non-gaming screens may introduce some latency. I observed this with a 4K screen that actually resampled the output to just 30Hz. I am pretty sure displays do not have this problem. Because there is no frame buffer, scrollers and such are perfectly smooth. If the TV renders the image at the speed it is sent over the HDMI link everything will be smooth. If HDMI is used for output, there is also output generated on the PAL output ( display connector ).

In the configuration menu you can change several setting regarding this port.

- **U64 Specific Settings**
  - HDMI Scan lines
- **User Interface Settings**
  - Interface Type ( overlay mode )

## 2.5.6 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, <i>NOT</i> 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, <i>NOT</i> 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.

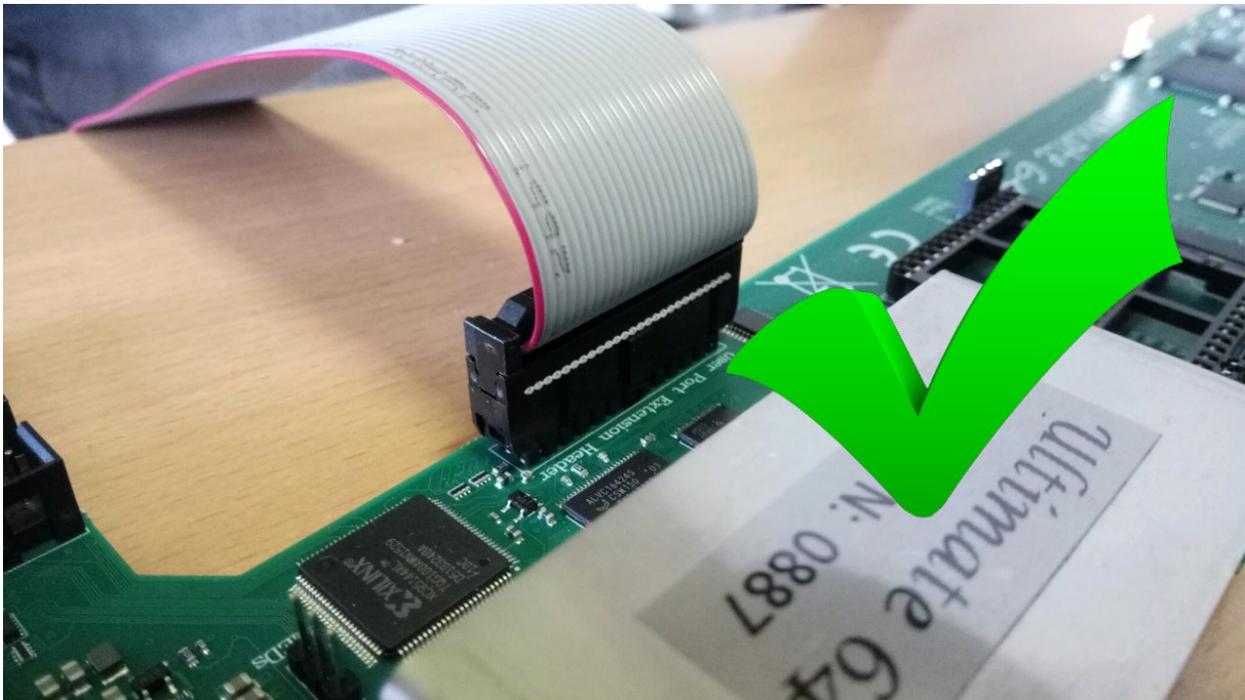
Pin 13 and P, the two left most pins on the header, are added for add features to the user port. One of the intended usages of these two pins is the generation of the “9 V~” on the user port extension board.

There is one other use 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.

In the LED Strip configuration menu, the use of pind 13 and P can be chosen. When the LED Strip is set to ‘off’, the 9 V~ generation is enabled.

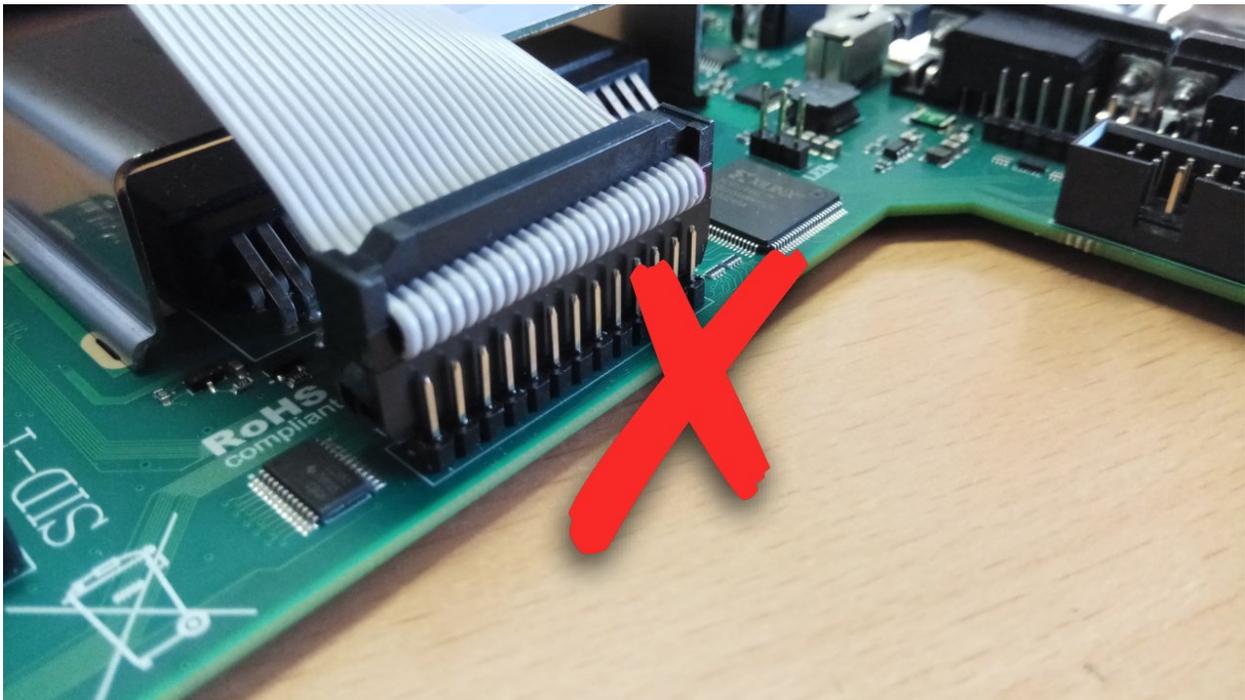
### Attaching the User Port Adapter

The user port adapter accessory should be connected using a 26-pin ribbon cable. Note that there is only ONE correct way to connect it, and other ways may result in damage of the U64 itself or to the accessory.

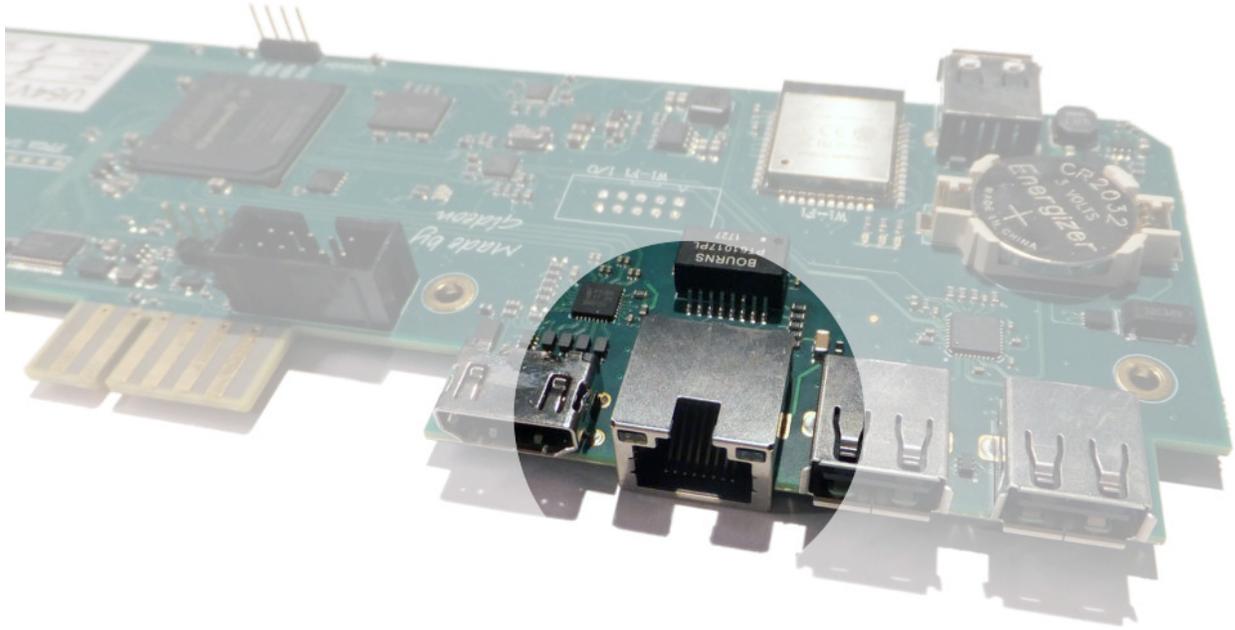


*Pay attention to the orientation!! The red wire should line up with pin 1!!!*

Please make sure the connector is not shifted a whole row, or to the left or to the right:



## 2.5.7 Ethernet port



The ethernet port can be connected to a switch to communicate with your Ultimate over your own local network. The Ultimate 1541-II+ and Ultimate 64 have an integrated ethernet port.

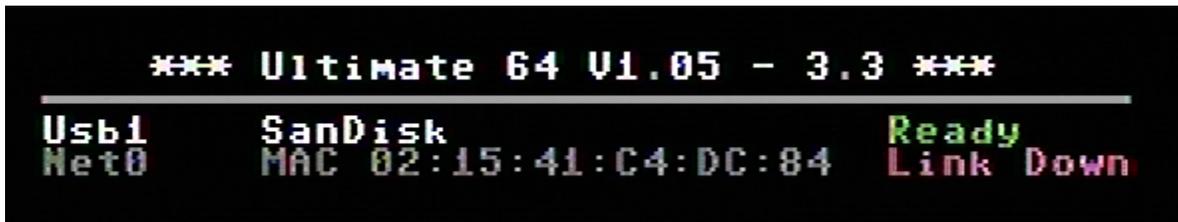


### *Ultimate 1541-II and compatible usb ethernet adaptor*

The Ultimate 1541-II needs a compatible USB Ethernet adaptor that is connected to the USB port of the Ultimate 1541-II. Any USB2LAN adaptor that uses an AX88772/-A/-B chip should work.

**Please note that the compatible USB Ethernet adaptors will ONLY be stable on the Ultimate 1541-II if the**

firmware < 3.2. They will work fine on the Ultimate 1541-II+ and Ultimate 64.

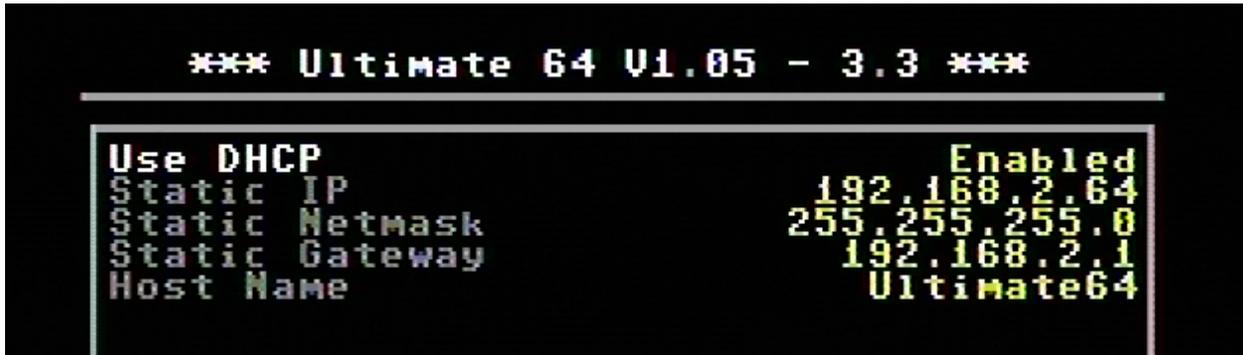


If your Ultimate product has an ethernet port, you can see this when entering the Ultimate menu. The picture above shows a **Net0** port, this indicates ethernet is accessible.

### Network settings

Within the network settings menu the ethernet port can be configured as needed, so it matches with your local network settings.

*The Network settings menu is only visible if a ethernet port is available.*



| Menu name           | Explanation  | Options (bold default)  |
|---------------------|--|-------------------------|
| Use DHCP            | Get IP settings from local DHCP Server on your network. Most home routers provide these settings by DHCP. If this is not the case please consult your internet/network provider. | Disabled <b>Enabled</b> |
| Static IP           | Set custom IP settings, DHCP has to be disabled. <i>This field can be left empty if DHCP is enabled.</i>   | Inputbox                |
| Static Network-mask | Set custom networkmask, DHCP has to be disabled. <i>This field can be left empty if DHCP is enabled.</i>   | Inputbox                |
| Static Gateway      | Set custom Gateway, DHCP has to be disabled. <i>This field can be left empty if DHCP is enabled.</i>   | Inputbox                |
| Host-name           | Set unique network hostname to identify your Ultimate product.   | Inputbox                |

### RR-net compatibility

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.

### The Ethernet port is used natively by the firmware

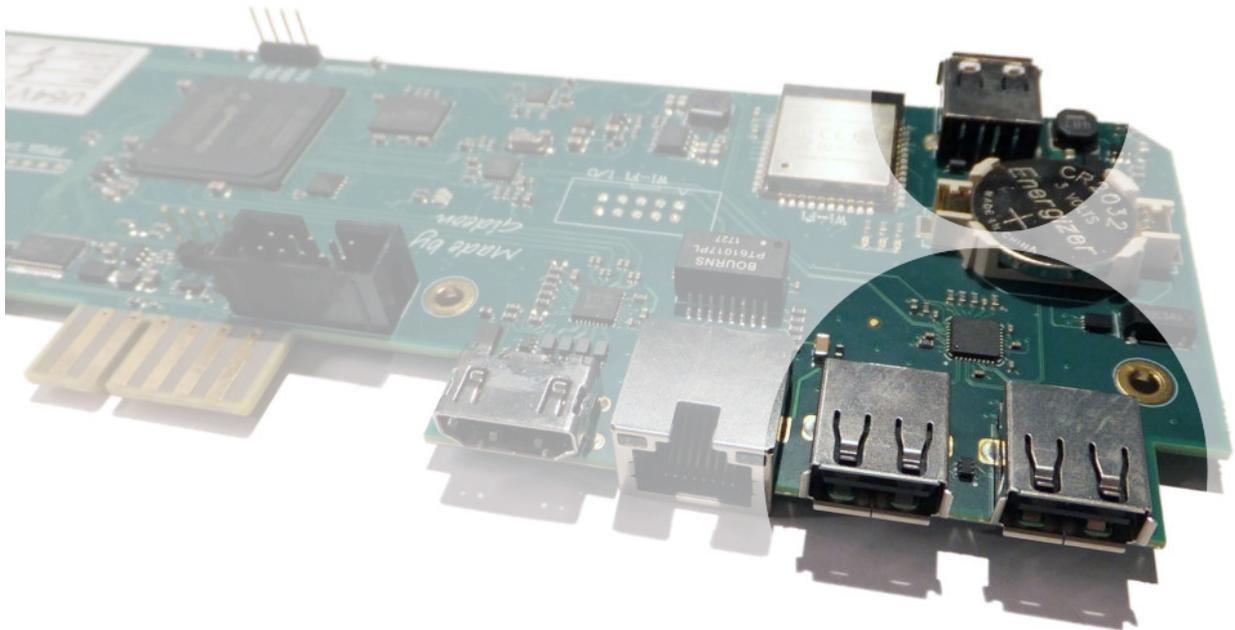
There is some primitive support for file-transfer using FTP (needs improvement), and it is possible to connect to the Ultimate using a VT-100 terminal program on the Telnet port (port 23). This gives the possibility to control the machine remotely, and swap disks without actually interrupting the program running on the C-64.

### Ultimate-related BBS and IRC clients

Since RR-net compatibility is not yet provided, some specific Ultimate software has been developed for accessing BBS and IRC networks. **Ulimite Lib** is a library (written by **Scott Hutter**) that gives easy access to the full TCP/IP stack that the Ultimate provides. This library comes along with two sample applications: **Ulimite Chat** and **Ulimite Term**, this one co-developed with **Francesco Sblendorio**.

*Applies to: Ultimate 1541-II, Ultimate 1541-II+, Ultimate 64*

## 2.5.8 USB ports



The Ultimate-64 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 (**no USB 3!!**) ports available on the board; two on the back and one on the “internal” side of the board/case.

|      |                            |
|------|----------------------------|
| Usb0 | External USB (next to NIC) |
| Usb1 | External USB (edge of PCB) |
| Usb2 | Internal USB               |

## 2.6 Data Streams

### 2.6.1 Introduction

#### Context

The Ultimate-64 is capable of streaming real time data over its built-in Ethernet port. Currently, there are two different types of streams that the machine can output:

- VIC Video Stream
- Audio Stream
- Debug Stream

This page describes these features in more detail.

#### Goal

This feature is intended for debugging, regression testing and analysis. However, there are more uses for it; such as making pixel-perfect recordings of a demo, or a digital audio recording without conversion to analog first and sampling it on a PC. Or, even a real time share over the internet to a friend!

### 2.6.2 Networking Background

The network streams are based on UDP. This means that they are connection-less, and can be captured off the network by the addressed node. UDP does not guarantee delivery, so it may be possible that packets get lost. However, on a local network this usually does not happen.

Aside from its simplicity, UDP has another advantage: it can be used to send data to multiple receivers at once. This is called ‘multicast’. The Ultimate is capable of sending the datastreams in unicast mode (to one specific IP address), in multicast mode (to a multicast IP address), or in broadcast mode. When the stream is transmitted in multicast mode, the receiver needs to ‘join’ the multicast group. Note that this will only work when the switch supports IGMP snooping, otherwise the switch will broadcast the data over all of its network ports; thus treating the packets as broadcast packets.

When the switch supports IGMP snooping, it will ‘see’ the network packet that is generated by the client who wants to receive the stream when it joins the multicast group. Such a request is sent using the IGMP protocol. Once the switch ‘sees’ this packet, it will enable the transmission of the requested stream to the physical port on the switch that requested the data (the port the PC is connected to). No other ports will receive the data, so the network is not flooded.

#### Unicast Example

When your switch does not support IGMP snooping, the use of unicast is recommended. Especially when there are other users of your local network, that are behind WiFi links, it is not recommended to flood the network and get angry looks from everyone else in your household.

Unicast is the simplest form. Let’s say your PC is at 192.168.0.100; either statically configured or obtained by DHCP, and your Ultimate has the IP address 192.168.0.64; again either statically configured or obtained from the DHCP server. You can then simply instruct the ultimate to stream the data to IP address 192.168.0.100.

The receiving software will open a socket, listening to a specific UDP port number. It is necessary to send the stream to this specific UDP port number, otherwise the stream cannot be received.

### Multicast Example

When using multicast, a specific range of IP addresses is used for transmission: 224.0.0.0 to 239.255.255.255. Some of these addresses are reserved for a specific type of communication, like IGMP, MDNS, and such.

Let's say the Ultimate is configured to send the stream to 239.0.1.64. This is in the free range for multicast on the local network (LAN). The PC application starts by telling the network infrastructure and its own routing tables that it wants to listen to 239.0.1.64. From that moment on, the stream is 'seen' by the PC and the application receives the data. Once the PC application is done, it 'leaves' the multicast group, and the PC ceases to receive the data.

Note that the IGMP switching is based on IP address. Therefore it is not possible to use the UDP port number to differentiate which stream to receive and which not. Use different multicast IP addresses if you like to receive more than one stream.

### 2.6.3 Starting and Stopping Streams

The available streams can be started and stopped in different ways. When the machine is turned on, it does not transmit any stream.

#### Using the menu

A stream can be started and stopped from the "action menu", which is brought up by pressing 'F5'. The start/stop options appear in that menu. When selected, the Ultimate will ask for the IP address to send the stream to. The default IP address is configured in the configuration screen "Data Streams". Note that changing the IP address in the configuration screen *does not* start or stop a stream; it is only the place where the last entered data is kept for later reuse.



The format of the destination is either an IP address, or a valid DNS name. The port number can be given as well, by adding it after a colon (:).



Examples:

| Destination string  | Meaning   |
|---------------------|---|
| 192.168.0.119:11000 | unicast address on the local network, port number 11000 |
| myserver.com        | unicast address, using DNS and default port number      |
| myserver.com:4567   | unicast address, using DNS and specific port number     |
| 239.0.1.64          | multicast address, using default port number            |
| 239.0.2.77:64738    | multicast address with port number specified            |

### Using the TCP command interface

Using the TCP socket '64', the following commands have been added to start and stop streams.

- Enable output stream: FF2n
- Disable output stream: FF3n

whereby 'n' is the stream number (see below)

The generic command structure is:

- <command word, little endian>
- <command parameter length, little endian>
- <command parameters>.

The Disable command does not take any parameters. The enable command can have two parameters; neither of them are required.

- Parameter 1: Duration of the stream enable (0 = forever)
- Parameter 2: Destination (string).

The duration is given in system ticks, which come at an interval of 5 ms.

So to elaborate on the commands:

To enable stream 0 for one second (200 ticks), to the pre-configured destination address, the bytes sent over the TCP control port are:

```
20 FF 02 00 00 C8
```

To enable stream 0 indefinitely to '192.168.0.119', you'd send:

```
20 FF 0F 00 00 00 192.168.0.119 (the latter part being ASCII)
```

-> Command length = string length + 2 bytes.

To disable stream 0, you send:

```
30 FF 00 00 (length of parameters is 0)
```

## 2.6.4 Available streams

### VIC Video Stream (ID 0)

The VIC Video Stream is the stream that presents the active part of the video output of the VIC. The ID of this stream is 0.

Each UDP datagram contains a header and pixel data. The header is as follows:

- Sequence number (16 bit LE)
- Frame number (16 bit LE)
- Line number (16 bit LE). If this is the last packet of the frame, bit 15 will be set.
- Pixels per line (16 bit LE), always 384
- Lines per packet (8 bit), always 4
- Bits per pixel (8 bit), always 4
- Encoding type (16 bit), always 0 for now. May be '1' later for RLE encoded data.

*Example packet:*

The following packet contains data of the third frame, line 100 - 103, starting with dark blue:

```
A1 00 02 00 64 00 80 01 04 04 00 00 66 66 66 66 66 66 66 ...  
seq #|frm #|line#|width|lp|bp|-enc-|data.....
```

So in total, the pixel data is preceded with 12 bytes of header data. The header is followed by pixel data, coded in 4-bit VIC colors, little endian, thus nibble 3..0 first. 4 lines of 384 pixels, equals 768 bytes of pixel data. Total UDP datagram = 780 bytes.

To capture an entire frame, you first wait for a packet with bit 15 set of the line number, then capture until you get another packet with bit 15 set of the line number. You should then have 68 packets of 4 lines (totaling 272 lines). Note that the video is cropped to 384 x 272, and aligned with the reference images of the VICE test suite. The actual output to the screen is 400 x 288 in PAL mode.

In NTSC mode, the output stream carries 384 x 240 pixels. The actual output to the screen is 400 x 240.

## Audio Stream (ID 1)

The Audio stream is taken from the output of the audio mixer. Thus, the stream received over the network contains the same data as the data sent over HDMI and back to the audio codec for conversion to the analog signal that is available on the DIN connector. The ID of this stream is 1.

The format of the audio stream is simpler than the video stream. The only two bytes that are sent as a header in front of the raw audio data is the sequence number of the packet, since the stream was enabled. This allows for detection of missing packets.

The sequence number is followed by 192 stereo samples in 16-bit signed, little endian format; left and right interleaved, starting with the left channel. Thus, the total UDP packet size is 770 bytes: 2 header bytes, and 192 times 4 bytes per sample:

```
00 00 fe ff 02 00 ff ff 03 00 fd ff 00 00 ...
-seq- left--right-left--right-left--right-...

01 00 ff ff 03 00 fd ff 00 00 03 00 ff ff ...
-seq- left--right-left--right-left--right-...

02 00 fd ff 03 00 fd ff 00 00 fe ff 02 00 ...
-seq- left--right-left--right-left--right-...
```

The sample rate of the stream is close to 48000 Hz. It depends on the video mode. The actual sample rate for PAL is:

$$(F_c * 16/9 * 15 / 77 / 32) = 47983 \text{ Hz} \quad (F_c = 4433618.75 \text{ Hz}) \quad (48\text{kHz}: -356 \text{ ppm})$$

For NTSC, the audio clock is derived as follows:

$$(F_c * 16/7 * 15 / 80 / 32) = 47940 \text{ Hz} \quad (F_c = 3579545.45 \text{ Hz}) \quad (48\text{kHz}: -1243 \text{ ppm})$$

## Debug Stream (ID 2)

### This is an advanced feature

The Debug stream is new in version 3.7 of the firmware (V1.28 and higher). It streams the CPU, VIC or 1541 CPU accesses directly to the network. What does this mean? It means that the program flow and memory accesses can be traced *real time* from the machine. This essentially opens up the possibility to trace program flow and timing, down to clock cycle accuracy. In addition, by adding the CPU access of 1541 Drive A to the possible output streams, interaction between the host machine and the drive can be analyzed.

Due to the bandwidth limitation of the 100 Mbps network port, it cannot be used in combination with the Video Stream (ID 0), nor can all three stream sources be used at the same time. Each stream occupies roughly 32 Mbps!

The following modes are supported:

- 6510 Only

- VIC Only
- 6510 & VIC
- 1541 Only
- 6510 & 1541

Each cycle / memory access occupies one 32-bit word in the output stream. The format of the 6510 and VIC streams are equal, with the exception of bit 31, which literally indicates the state of the PHI2 signal during the access. Because VIC accesses can also occur when PHI2 = 1 (Bad lines, for instance), the distinction whether a cycle is a CPU or a VIC cycle is made based on AEC and PHI2.

The 1541 CPU cycle also occupies one 32-bit word, but the data format is slightly different. The 1541 stream also contains the state of the signals ATN, CLOCK and DATA from the IEC bus, such that the data flow over this cable can be seen as well.

The first 32-bit word consists of a 16-bit sequence number and a reserved 16-bit word. Following this first 32-bit word, 360 data entries follow, each 32-bit. Hence, the payload size of the datagrams is 1444 bytes:

```
05 16 00 00 xx xx xx xx yy yy yy yy ...
-seq- resvd |- entry 0 -|- entry 1 -|
```

The format of the data entries are as follows:

Table 2: Debug Stream Format

| bit                 | 31  | 30   | 29    | 28     | 27   | 26         | 25   | 24   | 23..16 | 15..0        |              |
|---------------------|-----|------|-------|--------|------|------------|------|------|--------|--------------|--------------|
| <b>6510<br/>VIC</b> | /   | PHI2 | GAME# | EXROM# | BA   | IRQ#       | ROM# | NMI# | R/W#   | Data         | Ad-<br>dress |
| <b>1541</b>         | '0' | ATN  | DATA  | CLOCK  | SYNC | BYTE_READY | IRQ# | R/W# | Data   | Ad-<br>dress |              |

One way to visualize this stream, is to capture it to a file using a python script, such as found in the repository: [grab\\_debug.py](#)

There is a preliminary tool to 'decode' the binary file that is captured. In the tools directory there is a 'dump\_bus\_trace.c', which is compiled by running 'make' in that directory. Dump\_bus\_trace converts the captured stream to a *vcd* file, or value change dump file, which can be viewed with GtkWave or any other software tool that can visualize it. This is all very preliminary. A lot of work needs to be done to find and visualize exactly that what you're looking for, since the files are very large. E.g. a disassembly of the captured CPU bus may come in very handy. It would be better to rewrite the messy 'C' tool as a set of Python scripts.

## 2.6.5 Viewing and recording

### Windows

Thanks to Martijn Wieland (TSB), there is a viewer for the stream for Windows. This tool can be obtained here: .

### Linux/Mac

Jimmy (DusteDdk) made a Linux viewer, more info check:

This version can also be compiled on Mac OS.

## Python scripts

Also there are example scripts in the 'python' directory of the ultimate repository to show how grabbing of video data and audio data is done. This example scripts can be seen here: [grab.py](#) and [grab\\_audio.py](#)

## 2.7 Ultimate SID player auto configuration

What this does, is to select the correct socket when the internal player is started. The autoconfig selects the socket based on what type of SID is found in the socket and for what type of SID the tune was written. If the type of SID is not found, it may revert to UltiSID. This means that it will look for a 6581 if the SID header indicates this. This may lead to confusing results if the SID type installed is 8580.

If the SID types are correct, it will set the address(es) correctly, as well as the panning:

- Single SID tunes will pan to center.
- 2SID (Stereo SID) will pan to L3/R3.
- 3SID will pan to L4/Center/R4.

So it is a best-effort algorithm that works best for single SID tunes and you have one 6581 and one 8580 installed.

The SID autoconfig temporarily overrules the user configured audio mixer settings with the automatic configuration!



### 3.1 Introduction

Starting from version 3.7, a lightweight modem emulation layer is provided in the firmware of the Ultimate. This modem layer is accessible through an emulated MOS 6551 ACIA chip. This chip was found in the SwiftLink cartridge, as well as some other ACIA based RS-232 cartridges of the time. This ACIA chip provides a virtual serial port to the C-64, which is accessed through the I/O space.

The modem emulation layer bridges the ACIA chip and the LAN port. The modem connects to a server (e.g. one that is running a bulletin board system) through the internet.

### 3.2 Configuration

In order to use the modem emulation layer, the ACIA needs to be enabled in the configuration menu of the Ultimate application. Secondly, a the terminal program needs to be used to access the serial port, e.g. CCGMS.

An example configuration could be:

```

** Ultimate 64 Elite V1.28 - 3.7 **

Modem Interface          ACIA / SwiftLink
ACIA (6551) Mode         DE00/NMI
Listening Port           3000
Do RING sequence (incoming)  Enabled
Drop connection on DTR=0  Enabled
CTS Behavior             Active (Low)
DCD Behavior             Active when connected
DSR Behavior             Active when connected
Modem Offline Text      /Usb0/offline.txt
Modem Connect Text     /Usb0/welcome.txt
Modem Busy Text         /Usb0/busy.txt

-F3=Help-

```

Please observe I/O range conflicts, this is *\*not\** enforced by the Ultimate application.

Once the ACIA chip is enabled in the I/O space, a terminal program can be started and configured. For example, the configuration of CCGMS will be shown here:

```

Dialer/Parameters
Auto-Dialer/Phonebook
Baud Rate - 19200
Duplex - Full
Modem Type - Swift / Turbo DE
Protocol - Punter
Theme - Classic CCGMS v5.5
Edit Macros
Load/Save Phone Book and Config.
View Author's Message
Press <RETURN> to abort.
Call Afterlife!!
afterlife.dynu.com:6400

```

Note that CCGMS uses the NMI line, and the SwiftLink is configured at \$DE00. This corresponds to the setting made in the Ultimate configuration menu.

Again: Please observe I/O range conflicts, this is *\*not\** enforced by the Ultimate application. If you are getting wrong characters in your terminal program, you likely have an I/O conflict. For instance, Retro Replay has registers at \$DE00, and will therefore conflict with the ACIA at \$DE00.

### 3.3 Modem Commands

The lightweight modem emulation supports a subset of the standard Hayes modem commands. These commands start with 'AT'.

| Command | Description   |
|---------|---|
| ATI     | Identify. This command prints the modem identification text message.  |
| ATZ     | Reset. This command resets the modem. Any existing connection will be dropped.  |
| ATH     | Hangup. This command terminates the current connection.   |
| ATD     | Dial. With this command an outgoing connection is initiated. The 'D' should be followed by another character, usually 'T' or 'P' for tone and pulse dialing. However, the Ultimate ignores this character. The domain name follows. The port number can be specified after a colon. This is optional; when the port number is not given, the Ultimate will attempt to connect to port 80. An example of such command is: <i>ATDTAFTERLIFE.DYNU.COM:6400</i> |
| ATA     | Answer. This command picks up the incoming call. This is a required command when the option 'Do RING sequence' is set to 'Enabled'. If this command is not given in time, the incoming call times out after a number of rings.  |
| ATO     | Online. Use this command to go back to an active connection, if it was interrupted by the +++ sequence.   |
| ATV     | Verbose mode. Recognized but ignored. Usually, such a command appears in the initialization string of a terminal program, such as StrikeTerm. It is followed by a digit.  |
| ATS     | Register Select. With this command the so called 'S'-registers can be read and set. Not all registers are supported, but some useful registers are S0 (auto answer), S1 (ring counter), S2 (escape char) and S12 (escape time). See Hayes modem specification for more details.   |
| +++     | Escape sequence. The actual character can be set with register S2, with defaults to '+'. When three of these characters are sent to the modem, and at least S12 'jiffies' expire (by default 50, thus one second), the modem switches to command mode, but the existing connection remains active. A command such as ATH can then be given.   |

### 3.4 Incoming connections

Incoming connections are also supported. This enables you to run a simple server on your C64, or maybe even a BBS! In the configuration can be seen that port 3000 is selected for incoming connections. When an external node on the network attempts to connect to TCP port 3000 of the Ultimate, this is recognized as an incoming connection. Depending on the current state of the modem, the following will happen:

| State        | Behavior   |
|--------------|--|
| Of-<br>fline | When DTR=0, it is assumed that the modem software is not running. This happens when the ACIA is not configured and thus not enabled. In this case, the connecting party will receive a message, which is defined by the file specified in the configuration (default: <i>/Usb0/offline.txt</i> ). If this file does not exist, the default message <b>Modem Software is currently not running...</b> is answered.  |
| Busy         | When the modem is currently already in a call, thus the modem has an active connection, the connecting party will receive a message, which is defined by the file specified in the configuration (default: <i>/Usb0/busy.txt</i> ). If this file does not exist, the default message <b>The modem you are connecting to is currently busy.</b> is answered.  |
| Ready        | The modem is configured and the software is ready to accept a call. In this case, the connecting party will receive a message, which is defined by the file specified in the configuration (default: <i>/Usb0/connect.txt</i> ). If this file does not exist, the default message <b>Welcome to the Modem Emulation Layer of the Ultimate!</b> is answered. Following this message the RING sequence will begin (if enabled in the configuration). This means that the terminal program will receive 'RING' messages, which it needs to answer with 'ATA' to answer. |

Note, that when the filename is set to an empty string, the message is suppressed; thus no message is being answered to the calling party.

### 3.5 Handshaking

In the configuration, the state of handshake lines that the terminal program 'sees' can be set. The state of these handshake lines are set when a connection is established or terminated. At these moments, the Ultimate will read the configuration and set the handshake lines accordingly. By default CTS is always active, and DCD and DSR are only active during an active connection.

All work Copyright © 2013 by  
Gideon's Logic Architectures  
All rights reserved.

## 4.1 Introduction

### 4.1.1 Context

The 'Ultimate-II command interface' feature is a 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. This 'Ultimate-II command Interface' is also abbreviated as 'UCI'. It is also implemented on the Ultimate-II+ and Ultimate-64 products.

The 'Ultimate-II command interface' is the communication layer between the C64 on one side and functional modules of the 1541 Ultimate-II / Ultimate-II+ / Ultimate 64 on the other side. Such a functional module takes a command, and returns data and status back to the user program on the C64.

There are a few functional modules, which are described in their own separate documents:

- "Ultimate DOS"; meant to open, read and write files and directories
- "Control Interface"; a collection of useful routines and calls to access U2/U2+/U64 features
- "Network Target"; an interface to directly access the TCP/IP network stack.

### 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:

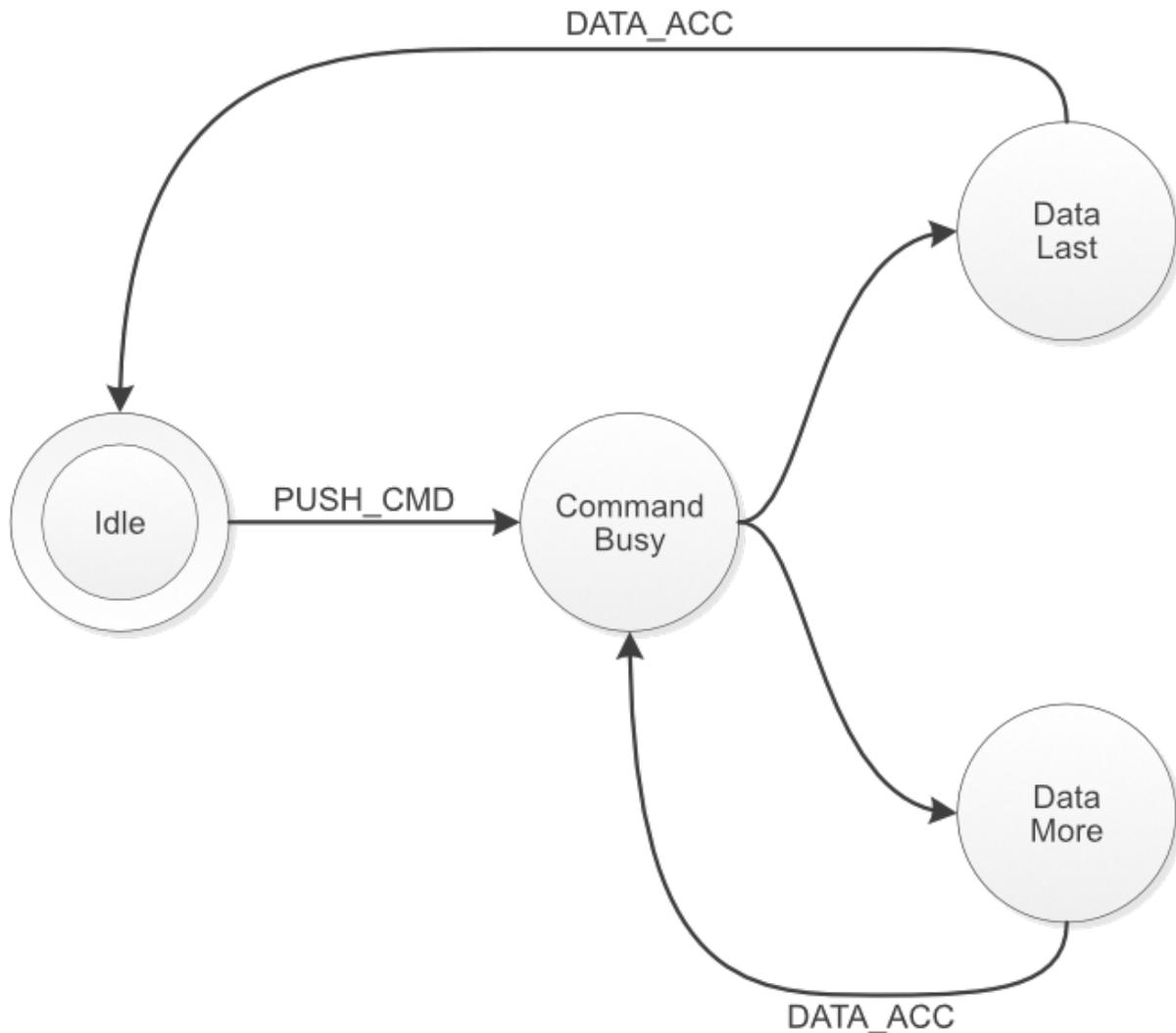


Figure 1: Basic Protocol State Machine

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.



---

## Ultimate-II Virtual Printer

---

By René Garcia Version: February 18<sup>th</sup> 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

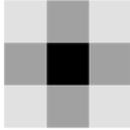
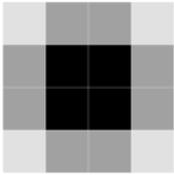
- **Printer Bus ID:** 4 or 5 (default is 4)  
This will assign device ID 4 or 5 to the printer.
- **Printer output file:** (default is `/SD/printer` on Ultimate II or `/Usb0/printer` on Ultimate II+)  
You can select file base name that the virtual printer will use to create the PNG files. If you choose 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 approximately 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             | •             |             |                      |                |

Continued on next page

Table 1 – continued from previous page

|                   | Commodore MPS             | Epson FX-80 | IBM Graphics Printer | IBM Proprinter  |
|-------------------|---------------------------|-------------|----------------------|-----------------|
| Overline          |                           |             |                      | •               |
| Backspace         |                           | •           | •                    | •               |
| Reverse page feed |                           | •           |                      |                 |
| CR=CR+LF          | •                         |             |                      | <i>optional</i> |
| LF=CR+LF          | •                         | •           |                      |                 |
| 7 dot BIM         | •                         |             |                      |                 |
| 8 dot BIM         |                           | •           | •                    | •               |
| 9 dot BIM         |                           | •           |                      |                 |
| HT Program        |                           | •           | •                    | •               |
| VT Program        |                           | •           |                      | •               |
| 60 dpi BIM        | • ( <i>double width</i> ) | •           | •                    | •               |
| 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 | £ | L | ■ |   |   |   | ■ | ■ | 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 |   | o |   |   | - |   | o |   | - |   | ┘ |
| 8 |   | (  | 8 | H | X |   | ♣ |   | ■ | - |   | ♣ | ■ | - |   | ┘ |
| 9 |   | )  | 9 | I | Y | ┘ |   |   | ┘ | ■ | ┘ |   | ┘ | ■ |   | ┘ |
| A |   | *  | : | J | Z | ┘ | ◆ |   |   | ┘ | ┘ | ┘ | ◆ |   | ┘ | ┘ |
| B |   | +  | ; | K | Æ | ┘ | + |   | ┘ | ■ | ┘ | + | ┘ | ■ |   | ┘ |
| C |   | ,  | < | L | Ø | L | ⌘ |   | ■ | ■ | L | Ø | ■ | ■ |   | ┘ |
| D |   | -  | = | M | Å | ┘ |   |   | ┘ | ┘ | ┘ | ┘ | ┘ | ┘ |   | ┘ |
| E |   | .  | > | N | ↑ | ┘ | π |   | ┘ | ■ | ┘ | π | ┘ | ■ |   | ┘ |
| F |   | /  | ? | O | ← | ┘ | ▤ |   | - | ■ | ┘ | ▤ | - | ■ |   | ┘ |

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   | ` | ¶ |   |   |   | ø | ` | ¶ |   | ø |   |
| 1 |   | !  | 1 | A | Q   | ◄ | ► |   |   |   | l | à | ◄ | ► | l | à |
| 2 |   | ”  | 2 | B | R   | — | ∕ |   |   |   | ˆ | è | — | ∕ | ˆ | è |
| 3 |   | #  | 3 | C | S   | ■ | ■ |   |   |   | + | ì | ■ | ■ | + | ì |
| 4 |   | \$ | 4 | D | T   | ◄ | ◄ |   |   |   | ˆ | ò | ◄ | ◄ | ˆ | ò |
| 5 |   | %  | 5 | E | U   | ◄ | ◄ |   |   |   | ˆ | ù | ◄ | ◄ | ˆ | ù |
| 6 |   | &  | 6 | F | V   | ` | — |   |   |   | — | â | ` | — | â |   |
| 7 |   | ’  | 7 | G | W   | ∕ | ■ |   |   |   | + | é | ∕ | ■ | + | é |
| 8 |   | (  | 8 | H | X   | ■ | ■ |   |   |   | ˆ | î | ■ | ■ | ˆ | î |
| 9 |   | )  | 9 | I | Y   |   | — |   |   |   | ˆ | ô |   | — | ˆ | ô |
| A |   | *  | : | J | Z   |   | ■ |   |   |   | ˆ | û |   | ■ | ˆ | û |
| B |   | +  | ; | K | [   | \ | ë |   |   |   | + | ä | \ | ë | + | ä |
| C |   | ,  | < | L | \   | L | ï |   |   |   | £ | ö | L | ï | £ | ö |
| D |   | -  | = | M | ] / | ◊ |   |   |   |   | ’ | ü | / | ◊ | ’ | ü |
| E |   | .  | > | N | ↑   | — | π |   |   |   | ˆ | β | — | π | ˆ | β |
| F |   | /  | ? | O | —   | Γ | ç |   |   |   | ” | é | Γ | 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 |   |   |   | ø | ` | P |   | ø |   |
| 1 |   | !  | 1 | a | q   | A | Q |   |   |   | l | à | A | Q | l | à |
| 2 |   | ”  | 2 | b | r   | B | R |   |   |   | ˆ | è | B | R | ˆ | è |
| 3 |   | #  | 3 | c | s   | C | S |   |   |   | + | ì | C | S | + | ì |
| 4 |   | \$ | 4 | d | t   | D | T |   |   |   | ˆ | ò | D | T | ˆ | ò |
| 5 |   | %  | 5 | e | u   | E | U |   |   |   | ˆ | ù | E | U | ˆ | ù |
| 6 |   | &  | 6 | f | v   | F | V |   |   |   | — | â | F | V | — | â |
| 7 |   | ’  | 7 | g | w   | G | W |   |   |   | + | é | G | W | + | é |
| 8 |   | (  | 8 | h | x   | H | X |   |   |   | ˆ | î | H | X | ˆ | î |
| 9 |   | )  | 9 | i | y   | I | Y |   |   |   | ˆ | ô | I | Y | ˆ | ô |
| a |   | *  | : | j | z   | J | Z |   |   |   | ˆ | û | J | Z | ˆ | û |
| b |   | +  | ; | k | [   | K | ë |   |   |   | + | ä | K | ë | + | ä |
| c |   | ,  | < | l | \   | L | ï |   |   |   | £ | ö | L | ï | £ | ö |
| d |   | -  | = | m | ] / | M | ◊ |   |   |   | ’ | ü | / | ◊ | ’ | ü |
| e |   | .  | > | n | ↑   | N | π |   |   |   | ˆ | β | N | π | ˆ | β |
| 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 | ` | ┘ |   |   |   | @ | ` | ┘ |   |   |   |
| 1 | !  | 1 | A | Q | ◀ | ▶ |   |   |   |   | ı | µ | ◀ | ▶ | ı | ◀ |
| 2 | ”  | 2 | B | R | — | ┘ |   |   |   |   | ı | à | — | ┘ | ı | — |
| 3 | #  | 3 | C | S | — | ■ |   |   |   |   | ı | ù | — | ■ | ı | — |
| 4 | \$ | 4 | D | T | — | ┘ |   |   |   |   | ı | â | — | ┘ | ı | — |
| 5 | %  | 5 | E | U | — | ■ |   |   |   |   | ı | ê | — | ■ | ı | — |
| 6 | &  | 6 | F | V | — | ┘ |   |   |   |   | ı | î | — | ┘ | ı | — |
| 7 | ’  | 7 | G | W | ┘ | ■ |   |   |   |   | ı | ô | ┘ | ■ | ı | ┘ |
| 8 | (  | 8 | H | X | ■ | — |   |   |   |   | ı | û | ■ | — | ı | ■ |
| 9 | )  | 9 | I | Y | ı | — |   |   |   |   | ı | ÿ | ı | — | ı | ı |
| A | *  | : | J | Z | ı | ■ |   |   |   |   | ı | ÿ | ı | ■ | ı | ı |
| B | +  | ; | K | [ | ┘ | ■ |   |   |   |   | ı | Ä | ┘ | ■ | ı | ┘ |
| C | ,  | < | L | \ | L | ┘ |   |   |   |   | ı | ö | L | ┘ | ı | L |
| D | -  | = | M | ] | ┘ | ■ |   |   |   |   | ı | ü | ┘ | ■ | ı | ┘ |
| E | .  | > | N | ↑ | — | π |   |   |   |   | ı | ß | — | π | ı | — |
| F | /  | ? | O | — | ┘ | — |   |   |   |   | ı | ^ | ┘ | — | ı | 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 |   |   |   |   | ı | à | A | Q | ı | à |
| 2 | ”  | 2 | b | r | B | R |   |   |   |   | ı | è | B | R | ı | è |
| 3 | #  | 3 | c | s | C | S |   |   |   |   | ı | ì | C | S | ı | ì |
| 4 | \$ | 4 | d | t | D | T |   |   |   |   | ı | ò | D | T | ı | ò |
| 5 | %  | 5 | e | u | E | U |   |   |   |   | ı | ù | E | U | ı | ù |
| 6 | &  | 6 | f | v | F | V |   |   |   |   | ı | â | F | V | ı | â |
| 7 | ’  | 7 | g | w | G | W |   |   |   |   | ı | ê | G | W | ı | ê |
| 8 | (  | 8 | h | x | H | X |   |   |   |   | ı | î | H | X | ı | î |
| 9 | )  | 9 | i | y | I | Y |   |   |   |   | ı | ÿ | I | Y | ı | ÿ |
| a | *  | : | j | z | J | Z |   |   |   |   | ı | ÿ | J | Z | ı | ÿ |
| b | +  | ; | k | [ | K | Ä |   |   |   |   | ı | ä | K | Ä | ı | ä |
| c | ,  | < | l | \ | L | Ö |   |   |   |   | ı | ö | L | Ö | ı | ö |
| d | -  | = | m | ] | M | Ü |   |   |   |   | ı | ü | M | Ü | ı | ü |
| e | .  | > | n | ↑ | N | π |   |   |   |   | ı | ß | N | π | ı | ß |
| f | /  | ? | o | — | O | — |   |   |   |   | ı | é | O | — | ı | 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 | [ | \ | i |   |   |   | ⊕ | ÿ | \ | ë | ⊕ | ÿ |
| C |   | ,  | < | L | \ | L | ¿ |   |   |   | £ | ü | L | ¿ | £ | Ü |
| D |   | -  | = | M | ] | / | ■ |   |   |   | ’ | ñ | / | ° | ’ | Ñ |
| E |   | .  | > | N | ↑ | ▬ | π |   |   |   | ♣ | ♦ | ▬ | π | ♣ | ♦ |
| F |   | /  | ? | O | — | ⏏ | ⏏ |   |   |   | ” | ç | ⏏ | ç | ” | Ç |

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 | i |   |   |   | ⊕ | ÿ | K | i | ⊕ | ÿ |
| 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 | ” | Ç |

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 | - | ∟ |   |   |   |   | r | - | ∟ |   | r |
| 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 |   | o |   |   |   |   | - |   | o |   | - |
| 8 |   | (  | 8 | H | X |   | ♣ |   |   |   | ■ | - |   | ♣ | ■ | - |
| 9 |   | )  | 9 | I | Y | \ |   |   |   |   | ▤ | ■ | \ |   | ▤ | ■ |
| A |   | *  | : | J | Z | \ | ♦ |   |   |   |   | ∟ | \ | ♦ |   | ∟ |
| B |   | +  | ; | K | Ä | / | + |   |   |   | † | ■ | / | + | † | ■ |
| C |   | ,  | < | L | Ö | L | ⊗ |   |   |   | ■ | ■ | L | ⊗ | ■ | ■ |
| 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 |   |   |   |   | r | - | P |   | r |
| 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 | ◀ | ▶ |   |   |   | l | à | ◀ | ▶ | l | à |
| 2 |   | ”  | 2 | B | R | — | ˘ |   |   |   | l | è | — | ˘ | l | 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 | ■ | — |   |   |   | r | î | ■ | — | r | î |
| 9 |   | )  | 9 | I | Y |   | — |   |   |   | ± | ô |   | — | ± | ô |
| A |   | *  | : | J | Z |   | ■ |   |   |   | ± | ù |   | ■ | ± | ù |
| B |   | +  | ; | K | [ | \ | ë |   |   |   | ± | ä | \ | ë | ± | ä |
| C |   | ,  | < | L | \ | L | ÿ |   |   |   | £ | ö | L | ÿ | £ | ö |
| D |   | -  | = | M | ] | / | ² |   |   |   | ’ | ü | / | ² | ’ | ü |
| E |   | .  | > | N | ↑ | — | π |   |   |   | ^ | β | — | π | ^ | β |
| F |   | /  | ? | O | — | Γ | ç |   |   |   | ” | é | Γ | 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 |   |   |   | l | à | A | Q | l | à |
| 2 |   | ”  | 2 | b | r | B | R |   |   |   | l | è | B | R | l | 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 |   |   |   | r | î | H | X | r | î |
| 9 |   | )  | 9 | i | y | I | Y |   |   |   | ± | ô | I | Y | ± | ô |
| a |   | *  | : | j | z | J | Z |   |   |   | ± | ù | J | Z | ± | ù |
| b |   | +  | ; | k | [ | K | ë |   |   |   | ± | ä | K | ë | ± | ä |
| c |   | ,  | < | l | \ | L | ÿ |   |   |   | £ | ö | L | ÿ | £ | ö |
| d |   | -  | = | m | ] | M | ² |   |   |   | ’ | ü | M | ² | ’ | ü |
| e |   | .  | > | n | ↑ | N | π |   |   |   | ^ | β | N | π | ^ | β |
| 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 |   |   | /  | /  | A | Q | a | q |   |
| 2 |   | "  | 2 | B | R | b | r |   |   | "  | "  | B | R | b | r |   |
| 3 |   | #  | 3 | C | S | c | s |   |   | #  | #  | C | S | c | s |   |
| 4 |   | \$ | 4 | D | T | d | t |   |   | \$ | \$ | D | T | d | t |   |
| 5 |   | %  | 5 | E | U | e | u |   |   | %  | %  | E | U | e | u |   |
| 6 |   | &  | 6 | F | V | f | v |   |   | &  | &  | F | V | f | v |   |
| 7 |   | '  | 7 | G | W | g | w |   |   | '  | '  | G | W | g | w |   |
| 8 |   | (  | 8 | H | X | h | x |   |   | (  | (  | H | X | h | x |   |
| 9 |   | )  | 9 | I | Y | i | y |   |   | )  | )  | 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 | â |    | 0 | @ | P | ` | p | à | â |    | 0  | @ | P | ` | p |
| 1 | è | é | !  | 1 | A | Q | a | q | è | é | /  | /  | A | Q | a | q |
| 2 | ù |   | "  | 2 | B | R | b | r | ù |   | "  | "  | B | R | b | r |
| 3 | ò |   | #  | 3 | C | S | c | s | ò |   | #  | #  | C | S | c | s |
| 4 | ì |   | \$ | 4 | D | T | d | t | ì |   | \$ | \$ | D | T | d | t |
| 5 | ° | ø | %  | 5 | E | U | e | u | ° | ø | %  | %  | E | U | e | u |
| 6 | £ | · | &  | 6 | F | V | f | v | £ | · | &  | &  | F | V | f | v |
| 7 | Ä | ' |    | 7 | G | W | g | w | Ä | ' |    |    | G | W | g | w |
| 8 | Ö | ( |    | 8 | H | X | h | x | Ö | ( |    |    | H | X | h | x |
| 9 | Û | ) |    | 9 | I | Y | i | y | Û | ) |    |    | 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 | ë | . | >  | N | ^ | n | ~ |   | ë | . | .  | 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      | #   | \$  | @   | [   | \   | ]   | ^   | `   | (   |     | )   | ~   |
| USA        | #   | \$  | @   | [   | \   | ]   | ^   | `   | (   |     | )   | ~   |
| France     | #   | \$  | à   | °   | ç   | û   | ^   | `   | é   | ù   | è   | ~   |
| Germany    | #   | \$  | ä   | Ä   | ö   | ü   | ^   | `   | ä   | ö   | ä   | ü   |
| UK         | £   | \$  | @   | [   | \   | ]   | ^   | `   | (   |     | )   | ~   |
| Denmark I  | #   | \$  | @   | Æ   | Ø   | Å   | ^   | `   | æ   | ø   | å   | ~   |
| Sweden     | #   | ¤   | É   | Å   | Ö   | Ä   | Ü   | É   | ä   | ö   | å   | ü   |
| Italy      | #   | \$  | @   | °   | ñ   | é   | ^   | ù   | à   | ò   | è   | ì   |
| Spain      | ₧   | \$  | @   | í   | ñ   | ç   | ^   | ù   | ñ   | ñ   | )   | ~   |
| Japan      | #   | \$  | @   | [   | ¥   | ]   | ^   | `   | (   |     | )   | ~   |
| 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 | í | ó | ú | ñ | ñ | ñ | ñ | ñ |
| 1 | !  | 1 | A | Q | a | q |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| 2 | ”  | 2 | B | R | b | r |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| 3 | #  | 3 | C | S | c | s |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| 4 | \$ | 4 | D | T | d | t |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| 5 | %  | 5 | E | U | e | u |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| 6 | &  | 6 | F | V | f | v |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| 7 | '  | 7 | G | W | g | w |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| 8 | (  | 8 | H | X | h | x |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| 9 | )  | 9 | I | Y | i | y |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| A | *  | : | J | Z | j | z |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| B | +  | ; | K | [ | k | [ |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| C | ,  | < | L | \ | l | l |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| D | -  | = | M | ] | m | ] |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| E | .  | > | N | ^ | n | ^ |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |
| F | /  | ? | O | _ | o | _ |   | í | ó | ú | ñ | ñ | ñ | ñ | ñ | ñ |

### 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 |   | l | h | q | ≡ |   |
| 1 |   | !  | 1 | A | Q | a | q | ü | æ | í |   | l | h | q | ≡ |   |
| 2 |   | ”  | 2 | B | R | b | r | é | œ | ó |   | l | h | q | ≡ |   |
| 3 | ♥ | #  | 3 | C | S | c | s | â | ø | ú |   | l | h | q | ≡ |   |
| 4 | ♦ | \$ | 4 | D | T | d | t | ä | ö | ñ |   | l | h | q | ≡ |   |
| 5 | ♣ | %  | 5 | E | U | e | u | à | ò | ñ |   | l | h | q | ≡ |   |
| 6 | ♠ | &  | 6 | F | V | f | v | â | ô | ñ |   | l | h | q | ≡ |   |
| 7 |   | '  | 7 | G | W | g | w | ç | ù | ö |   | l | h | q | ≡ |   |
| 8 |   | (  | 8 | H | X | h | x | é | ÿ | ö |   | l | h | q | ≡ |   |
| 9 |   | )  | 9 | I | Y | i | y | è | ÿ | ö |   | l | h | q | ≡ |   |
| A |   | *  | : | J | Z | j | z | è | ÿ | ö |   | l | h | q | ≡ |   |
| B |   | +  | ; | K | [ | k | [ | è | ÿ | ö |   | l | h | q | ≡ |   |
| C |   | ,  | < | L | \ | l | \ | è | ÿ | ö |   | l | h | q | ≡ |   |
| D |   | -  | = | M | ] | m | ] | è | ÿ | ö |   | l | h | q | ≡ |   |
| E |   | .  | > | N | ^ | n | ^ | è | ÿ | ö |   | l | h | q | ≡ |   |
| F |   | /  | ? | O | _ | o | _ | è | ÿ | ö |   | l | h | q | ≡ |   |

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 |   | l | h | q | ≡ |   |
| 1 |   | !  | 1 | A | Q | a | q | ü | æ | í |   | l | h | q | ≡ |   |
| 2 |   | ”  | 2 | B | R | b | r | é | œ | ó |   | l | h | q | ≡ |   |
| 3 | ♥ | #  | 3 | C | S | c | s | â | ø | ú |   | l | h | q | ≡ |   |
| 4 | ♦ | \$ | 4 | D | T | d | t | ä | ö | ñ |   | l | h | q | ≡ |   |
| 5 | ♣ | %  | 5 | E | U | e | u | à | ò | ñ |   | l | h | q | ≡ |   |
| 6 | ♠ | &  | 6 | F | V | f | v | â | ô | ñ |   | l | h | q | ≡ |   |
| 7 |   | '  | 7 | G | W | g | w | ç | ù | ö |   | l | h | q | ≡ |   |
| 8 |   | (  | 8 | H | X | h | x | é | ÿ | ö |   | l | h | q | ≡ |   |
| 9 |   | )  | 9 | I | Y | i | y | è | ÿ | ö |   | l | h | q | ≡ |   |
| A |   | *  | : | J | Z | j | z | è | ÿ | ö |   | l | h | q | ≡ |   |
| B |   | +  | ; | K | [ | k | [ | è | ÿ | ö |   | l | h | q | ≡ |   |
| C |   | ,  | < | L | \ | l | \ | è | ÿ | ö |   | l | h | q | ≡ |   |
| D |   | -  | = | M | ] | m | ] | è | ÿ | ö |   | l | h | q | ≡ |   |
| E |   | .  | > | N | ^ | n | ^ | è | ÿ | ö |   | l | h | q | ≡ |   |
| F |   | /  | ? | O | _ | o | _ | è | ÿ | ö |   | l | h | q | ≡ |   |

Israel

|   | 0 | 1  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---|---|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 |   |    | 0 | @ | P | ` | p | ן | ן | א | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 1 |   | !  | 1 | A | Q | a | q | ב | ב | א | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 2 |   | ”  | 2 | B | R | b | r | ג | ג | ב | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 3 | ♥ | #  | 3 | C | S | c | s | ד | ד | א | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 4 | ♦ | \$ | 4 | D | T | d | t | ה | ה | ב | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 5 | ♣ | %  | 5 | E | U | e | u | ו | ו | ג | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 6 | ♠ | &  | 6 | F | V | f | v | ז | ז | ד | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 7 |   | '  | 7 | G | W | g | w | ח | ח | ה | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 8 |   | (  | 8 | H | X | h | x | ט | ט | ו | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 9 |   | )  | 9 | I | Y | i | y | ך | ך | ז | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| A |   | *  | : | J | Z | j | z | ל | ל | ח | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| B |   | +  | ; | K | [ | k | [ | מ | מ | ט | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| C |   | ,  | < | L | \ | l | \ | נ | נ | ך | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| D |   | -  | = | M | ^ | m | ^ | ס | ס | ך | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| E |   | .  | > | N | ~ | n | ~ | ע | ע | ך | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| F |   | /  | ? | O | _ | o | _ | פ | פ | ך | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

Greece

|   | 0 | 1  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---|---|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 |   |    | 0 | @ | P | ` | p | Α | Ρ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 1 |   | !  | 1 | A | Q | a | q | Β | Σ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 2 |   | ”  | 2 | B | R | b | r | Γ | Τ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 3 | ♥ | #  | 3 | C | S | c | s | Δ | Υ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 4 | ♦ | \$ | 4 | D | T | d | t | Ε | Φ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 5 | ♣ | %  | 5 | E | U | e | u | Ζ | Χ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 6 |   | &  | 6 | F | V | f | v | Θ | Ψ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 7 |   | '  | 7 | G | W | g | w | Ι | Ω | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 8 |   | (  | 8 | H | X | h | x | Κ | Α | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 9 |   | )  | 9 | I | Y | i | y | Β | Ρ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| A |   | *  | : | J | Z | j | z | Σ | Τ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| B |   | +  | ; | K | [ | k | [ | Υ | Φ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| C |   | ,  | < | L | \ | l | \ | Χ | Ψ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| D |   | -  | = | M | ^ | m | ^ | Ω | Ξ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| E |   | .  | > | N | ~ | n | ~ | Ο | Π | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| F |   | /  | ? | O | _ | o | _ | Φ | Χ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

Portugal

|   | 0 | 1  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---|---|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 |   |    | 0 | @ | P | ` | p | ç | é | á |   |   |   |   |   |   |
| 1 |   | !  | 1 | A | Q | a | q | ú | æ | í |   |   |   |   |   |   |
| 2 |   | ”  | 2 | B | R | b | r | é | œ | ó |   |   |   |   |   |   |
| 3 | ♥ | #  | 3 | C | S | c | s | â | ø | ú |   |   |   |   |   |   |
| 4 | ♦ | \$ | 4 | D | T | d | t | ã | ö | ñ |   |   |   |   |   |   |
| 5 | ♣ | %  | 5 | E | U | e | u | à | ò | ñ |   |   |   |   |   |   |
| 6 | ♠ | &  | 6 | F | V | f | v | â | ô | õ |   |   |   |   |   |   |
| 7 |   | '  | 7 | G | W | g | w | ç | ù | ö |   |   |   |   |   |   |
| 8 |   | (  | 8 | H | X | h | x | ê | ÿ | ç |   |   |   |   |   |   |
| 9 |   | )  | 9 | I | Y | i | y | ë | ö | ã |   |   |   |   |   |   |
| A |   | *  | : | J | Z | j | z | è | ü | ä |   |   |   |   |   |   |
| B |   | +  | ; | K | [ | k | [ | í | í | á |   |   |   |   |   |   |
| C |   | ,  | < | L | \ | l | l | í | í | á |   |   |   |   |   |   |
| D |   | -  | = | M | ] | m | ] | í | í | á |   |   |   |   |   |   |
| E |   | .  | > | N | ^ | n | ^ | í | í | á |   |   |   |   |   |   |
| F |   | /  | ? | O | _ | o | _ | á | ó | 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 |   |   |   |   |   |   |
| 1 |   | !  | 1 | A | Q | a | q | ú | í | í |   |   |   |   |   |   |
| 2 |   | ”  | 2 | B | R | b | r | é | ó | ó |   |   |   |   |   |   |
| 3 | ♥ | #  | 3 | C | S | c | s | â | ø | ú |   |   |   |   |   |   |
| 4 | ♦ | \$ | 4 | D | T | d | t | ã | ö | ñ |   |   |   |   |   |   |
| 5 | ♣ | %  | 5 | E | U | e | u | à | ò | ñ |   |   |   |   |   |   |
| 6 | ♠ | &  | 6 | F | V | f | v | â | ô | õ |   |   |   |   |   |   |
| 7 |   | '  | 7 | G | W | g | w | ç | ù | ö |   |   |   |   |   |   |
| 8 |   | (  | 8 | H | X | h | x | ê | ÿ | ç |   |   |   |   |   |   |
| 9 |   | )  | 9 | I | Y | i | y | ë | ö | l |   |   |   |   |   |   |
| A |   | *  | : | J | Z | j | z | è | ü | l |   |   |   |   |   |   |
| B |   | +  | ; | K | [ | k | [ | í | í | ½ |   |   |   |   |   |   |
| C |   | ,  | < | L | \ | l | l | í | í | ¼ |   |   |   |   |   |   |
| D |   | -  | = | M | ] | m | ] | í | í | ¼ |   |   |   |   |   |   |
| E |   | .  | > | N | ^ | n | ^ | í | í | ¼ |   |   |   |   |   |   |
| F |   | /  | ? | O | _ | o | _ | á | é | é |   |   |   |   |   |   |

### 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 | <i>Draft Italic</i> | Near Letter Quality |
| ELITE            | Draft Regular | <i>Draft Italic</i> | Near Letter Quality |
| MICRO            | Draft Regular | <i>Draft Italic</i> | Near Letter Quality |
| CONDENSED        | Draft Regular | <i>Draft Italic</i> | Near Letter Quality |
| PICA COMPRESSED  | Draft Regular | <i>Draft Italic</i> | Near Letter Quality |
| ELITE COMPRESSED | Draft Regular | <i>Draft Italic</i> | Near Letter Quality |
| MICRO COMPRESSED | Draft Regular | <i>Draft Italic</i> | 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 | - | 7 |   |   |   | r | - | 7 |             | r |   | 0 |    |   | 0 | @ | p | - | P |   |   |   | r | - | P |   | r |   |
| 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 | - | X |   |   |   |   | ■ | ■ | - | X           | ■ | ■ | 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 | £ | L | ■ |   |   |   |   | ■ | ■ | L | ■           | ■ | ■ | C | ,  | < | l | £ | L | ■ |   |   |   | ■ | ■ | L | ■ | ■ | ■ |   |
| D             | -  | = | M | ] | \ |   |   |   |   |   | L | ] | \ |             | L | ] | D | -  | = | m | ] | M |   |   |   |   | L | ] | M |   | L | ] |   |
| E             | .  | > | N | ↑ | \ | π |   |   |   |   | ] | ■ | \ | π           | ] | ■ | E | .  | > | n | ↑ | N | ■ |   |   |   | ] | ■ | N | ■ | ] | ■ |   |
| F             | /  | ? | O | ← | ▣ | ▣ |   |   |   |   | - | ■ | ▣ | ▣           | - | ▣ | 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<br>New feature: ASCII output format |



---

## Interview RetroMagazine

---

*Interview with Gideon Zweijter, 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 crystallized 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 collector 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 Maarsse 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.

Interviewer: David La Monaca (aka Cercamon)

RetroMagazine Facebook Group - <https://www.facebook.com/RetroMagazine-2005584959715273>

Website - <http://www.retromagazine.net>

*Interview made in May-June, 2018 © 2018 David La Monaca, Gideon Zweijtzter and RetroMagazine*

Download the interview in PDF format (off-print from issue 8 of RetroMagazine) here: \_\_ <http://bit.ly/2NJXsEe>

---

## 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

- *FAQ for the Ultimate II and Ultimate II Plus cartridges*
  - *Information and resources for the Ultimate devices*
  - *Where can I find the latest firmware?*
  - *I am still running firmware 2.6k or lower on my U2. How can I upgrade?*
  - *How can I use the emulated SID as second SID for 2SID tunes?*
  - *Does the U2 and U2+ support Easyflash Cartridge images?*
  - *Which USB2LAN adapters are supported by the 1541Ultimate 2?*
  - *Can I control the Ultimate using a USB keyboard?*
  - *Can I play SID files from the High Voltage Sid Collection?*
  - *How do I use the built-in SID player*
  - *Can I play SID tunes using the network interface?*
  - *How do I use T64 files?*
  - *How do I create a directory*
  - *How do I create a blank disk image*
  - *How do I copy a disk image, directory or file to another location*
  - *Can I copy files from inside a disk image to the file system?*
  - *Can I copy files from the file system to a disk image?*

- *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?*
- *Flip/swap disk (mount the next disk without using the Ultimate menu)*
- *How about the C128 and C128D(CR). Does the Ultimate cartridge work on these machines?*
- *Disabling the internal C128D drive*

## 7.1 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](#).

## 7.2 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).

## 7.3 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](#).

## 7.4 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.

## 7.5 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 automatically. You can save it by "F5", "Save Easyflash crt" in the filebrowser. The file will be saved with the file name "module.crt". Optionally rename the saved file to a more recognizable name.

## 7.6 Which USB2LAN adapters are supported by the 1541Ultimate 2?

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

## 7.7 Can I control the Ultimate 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.

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

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

## 7.9 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                |
| space bar | pause / resume tune                |

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.

## 7.10 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 network 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.

## 7.11 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.

## 7.12 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.

## 7.13 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.

## 7.14 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+ does 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.

## 7.15 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.

## 7.16 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.

## 7.17 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.

## 7.18 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.

## 7.19 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](http://rr.c64.org/wiki/1541_Ultimate#Documentation)

## 7.20 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](http://rr.c64.org) is also a great place to find some manuals.

## 7.21 Flip/swap disk (mount the next disk without using 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.

## 7.22 How about the C128 and C128D(CR). Does the Ultimate cartridge work on these machines?

Yes, the Ultimate cartridges work on the C128, C128D(CR) but with some limitations. Bart was so kind to write down his findings and advice on how to get the most out of your C128 combined with the U2+: <https://www.bartsplace.net/content/publications/1541ultimate128.shtml>

## 7.23 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.