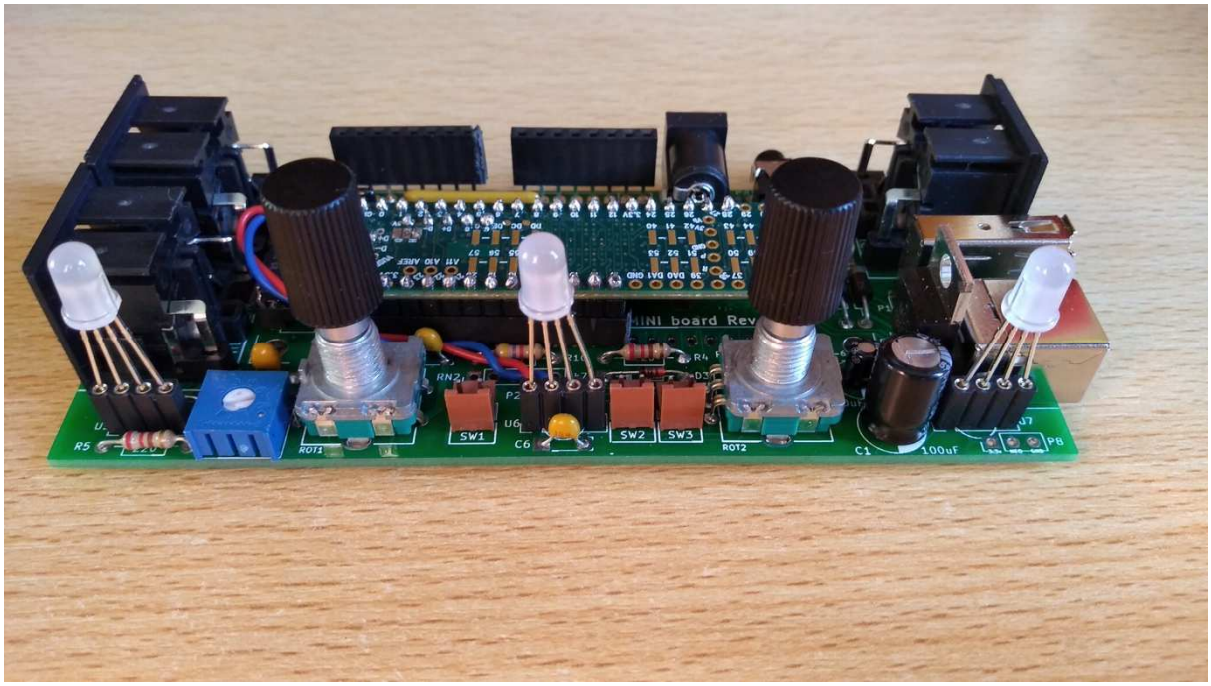
V-Controller MINI production model building guide
Version 1.1
By sixeight at vguitarforums.com



Introduction

Here is a quick guide for building the VC-MINI, a dedicated MIDI controller for Boss GP-10 / Roland GR-55 / Roland VG-99 / Zoom G3 / Zoom MS70-CDR / Line6 M13 / Line6 Helix / Fractal AxeFX / Boss Katana and the Kemper Profiling Amp. Building this device should cost around 4 hours and $100 -150 for parts, depending on the cost for the enclosure and the display.

Features of the VC-MINI:

Check out the VC-MINI User Guide for features.

Main parts of the VController:

The VController has the following main parts:

- 3D printed enclosure
- VController MINI PCB board.

Additional documents:

- STL files for the 3D printed enclosure:
- PDF with the schematic

Bill of materials: VC-mini

Reference	Num-ber	Part	Where to get
Display*	1	16x2 LCD character displays ERM1602DNS-4-5V*	Buydisplay.com: ERM1602DNS-4-5V
Display**	1	RGB backlight Positive or negative LCD 16x2**	Adafruit: 398 or 399
Display	1	16 or 18** pin header	reichelt.de: **SL 1X40G 2,54**
Display	1	Arduino stackable header kit R3. Use 8 + 8 or 6 + 10 pin (middle pins of display are not connected)	Sparkfun: **PRT-11417**
U5-U7	3	Neopixel LED 5mm (Neopixel or PL9823 F5)	Adafruit: 1938 Ebay (search for PL9823 F5)
U5-U7	3	Female header 2.54 mm, 1x4 straight Or 4 pin male header	reichelt.de: **MPE 115-1-004**
SW1-3	3	Footswitch	http://www.ebay.com/itm/271930278587
SW1-3 U5	3	PCB connector straight, brown, 2-pin (also for wire to USB port on Teensy)	reichelt.de**: PS 25/2G BR**
ROT1, ROT2	2	Rotary encoder Alps STECC11B03	reichelt.de: **STEC11B03**
ROT1, ROT2	2	Rotary knob for rotary axis 6mm	reichelt.de: **KNOPF 10-150B**
RV1	1	10k trimmer 10 mm horizontal	reichelt.de: **76-10 10K** **(test 64W-10k and 64Z-10k)**
U5	1	Teensy 3.6 or 3.2 or LC (without pins as the Teensy is mounted upside down!'	https://www.pjrc.com/store/teensy36.html reichelt.de: **TEENSY 3.6**
U5	1	Pins for Teensy	reichelt.de: **SL 1X40G 2,54**
U5	2	Socket for Teensy. 20 pins suffice for Teensy 3.6. Cut one into 14 pin + 5 pin (one pin butchered). See guide.	reichelt.de: **BL 1X20G 2,54** (socket)
U2	1	VO2630 dual optocoupler	reichelt.de: **VO 2630**
U1	1	uA7805 Voltage regulator	reichelt.de: **L 7805 CV**
U4	1	24LC512 I/P serial EEPROM	reichelt.de: **24LC512-I/P**
U5**	1	WS2811**	Adafruit: 1378
U1, U2	2	8 pin IC socket	reichelt.de: **GS 8**
JK1,JK2, JK3	3	7 pin din socket (MIDI) Cliff FM6727 Pro Signal PSG03465	Farnell: 1791759 or 2679728 reichelt.de does not stock these. Could use 5 pin **MABP 5S** instead if power is not needed
JK4	1	Power barrel – centre pin 2 mm	reichelt.de: **LUM NEB 21R** Farnell: 1737246
P7	1	1x Lumberg 1503-07 3,5mm stereo jack PCB	reichelt.de: **LUM 1503-07**
P3	1	1x USB male socket type B	reichelt.de: **USB BW**
P1	1	1 x USB A vertical	Reichelt.de: **USB AW-VL**
D1, D4, D5, D6, D7, D8	6	1N5817 shottky diode	reichelt.de: **1N 5817**
D2, D3	2	1N4148 diode	reichelt.de: **1N 4148**
C1	1	100 uF capacitor, >=16V	reichelt.de: **RAD FR 100/35**
C3	1	10 uF capacitor, >=16V	Reichelt.de: **SM 10/16RAD**
C2, C4, C5, C6, C7**	4* or 5**	100 nF capacitor	reichelt.de: **KERKO 100N**
RN1, RN2	2	Resistor network 4 res./5 pin 4k7 RN2 can be skipped.	reichelt.de: **SIL 5-4 4,7K**
R1, R2, R3, R6	1	Resistor network 4 res./8 pin 47	reichelt.de: **SIL 8-4 47**
R7, R8, R11,	1	Resistor network 4 res./8 pin 4k7	reichelt.de: **SIL 8-4 4,7K**

R13			
R10	1	4k7 resistor	reichelt.de: **1/4W 4,7k**
R4, R5	2	220 resistor	reichelt.de: **1/4W 220**
R12	1	470k resistor	reichelt.de: **1/4W 470K**
R9*	1	100 Ohms resistor*	reichelt.de: **1/4W 100**
	4	15mm spacer	reichelt.de: **DI 15mm**
	4	M3 x 12mm (black)	ebay
	4	M3 x 16mm (black)	ebay

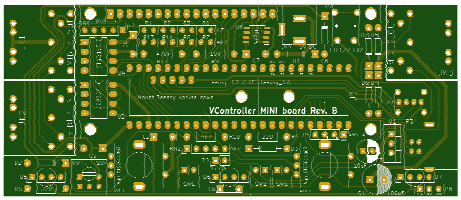
* Only for monochrome display ** Only for colored display

Power supply (optional)

	1	Compact switching power supply, 18W, out 9V	Reichelt.de: **PSAA 18U-090**

Building the Main PCB

PCB manufacturing:
Contact me to order a main PC board at SixEightSoundControl@gmail.com or by sending a pm to sixeight on vguitarforums.com.



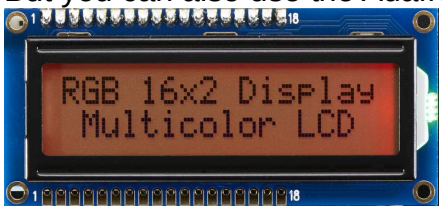
Options
To build the VC-mini, there are a few choices to be made.

Teensy 3.6, 3.2 or LC:
The VC-mini board is compatible with all these Teensy models.

1) Teensy 3.6 is the best option. It has plenty of memory and speed and most important it is the only Teensy with a USB host port, which you need for direct connection of the Katanas, the Boss GP-10 and the Zoom devices! All Teensies do have a working USB slave port. (GP-10 currently not working)
2) Teensy 3.2 is large enough to run the full VController code, but it does not have a USB host port.
3) Teensy LC is the cheapest, but it will not run the full sketch of the VController and it has no USB host port. But it may be just fine for your project.

Monochrome or RGB backlit display:
I really like the Buydisplay white on black monochrome display. It has the best visibility:

But you can also use the Adafruit RGB positive or negative displays:



When using an RGB backlit display R9 (100 Ohms) must be omitted and U5 (WS2811) and its capacitor (C7) must be put on the board. You can also use U5 to control the backlight of a monochrome display.

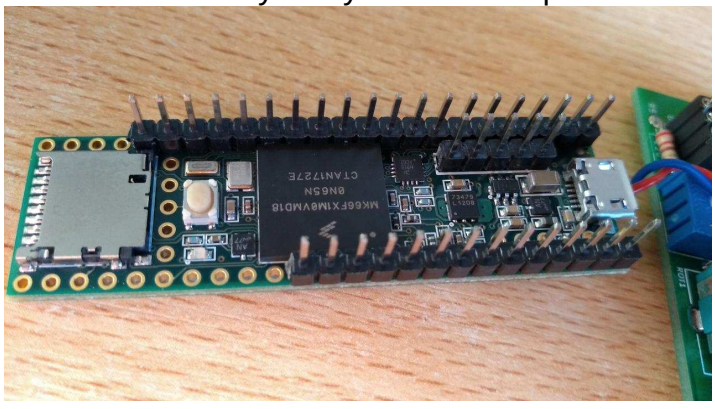
Do note that most 16x2 displays have the same PCB size, but the size of the bezel is different. There are different 3D print (stl) files for the the Buydisplay and the Adafruit displays. Use different branded displays at your own risk. In my opinion most white on blue displays have bad visibility!

Soldering:
I always solder starting with the parts with the least height. Then I work my way up to the parts with more height. Before soldering all the pins of the connectors, check if they fit the enclosure.

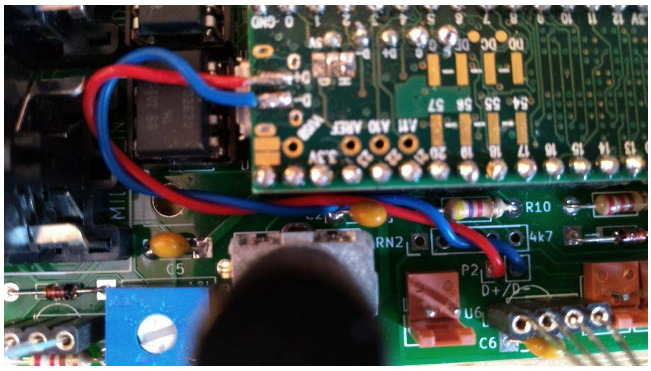
Soldering the Teensy:
For the Teensy I use two low profile 20 pin female headers:

The Teensy 3.6 has more than 20 pins, but not all pins are used.
One of the headers is cut into a 14 and a 5 pin header. The cut will butcher one pin.
The headers are connected to the board in the following way:

Also on the Teensy I only connect the pins that are in use:

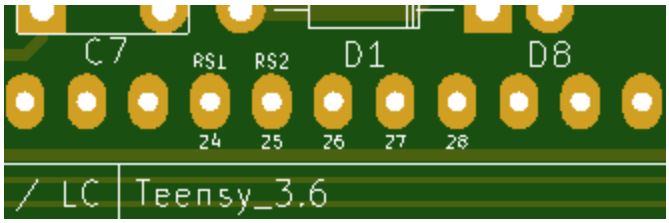


Two wires connect the D+ and D- pads on the Teensy to the D+ / D- connectors on the PCB:

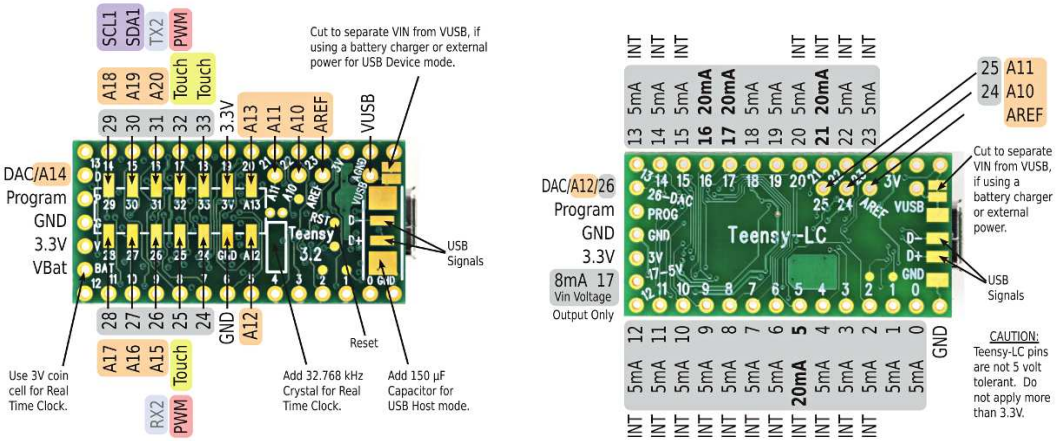


<u>Connecting the Teensy 3.2 or Teensy LC</u>

The 20 pin female headers can be cut to 14 pins for the Teensy 3.2 or LC. Use two wires to connect pin 24 and 25 from the board to the Teensy. Pin 24 and 25 are marked on the PCB.



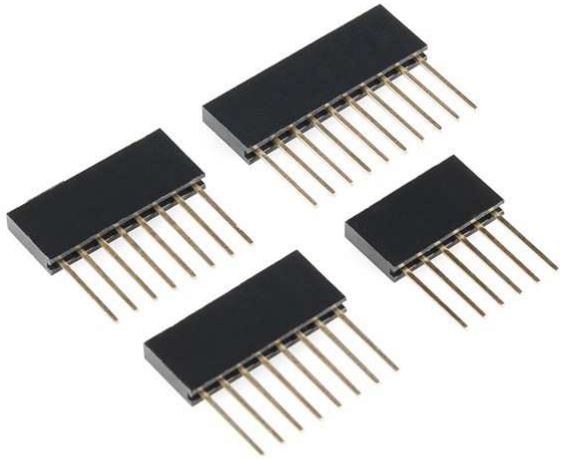
On the Teensy 3.2 these pins are pads and on the LC they are holes.



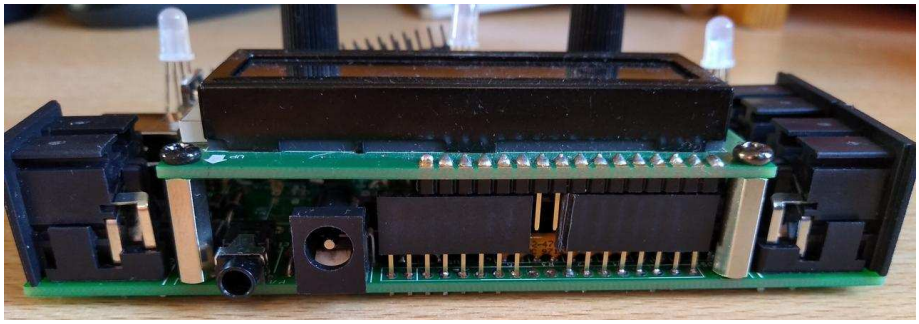
Pin 26 to 28 can also be extended, but only if you intend to use the connections for the extra switches (switch 4-6, see further modifications)

Also connect D+ and D- from the PCB to the pads on the Teensy.

Adding the display:
The display is attached to the PCB using four 15 mm spacers. A standard 16 or 18 pin female header is too short to make the connection between the display and the PCB. So I use stackable headers. The Arduino Stackable Header Kit R3 is just fine for the job:



Before cutting the pins of the header, make sure you put the spacers in place and push the female header up to the display, so it all fits properly:

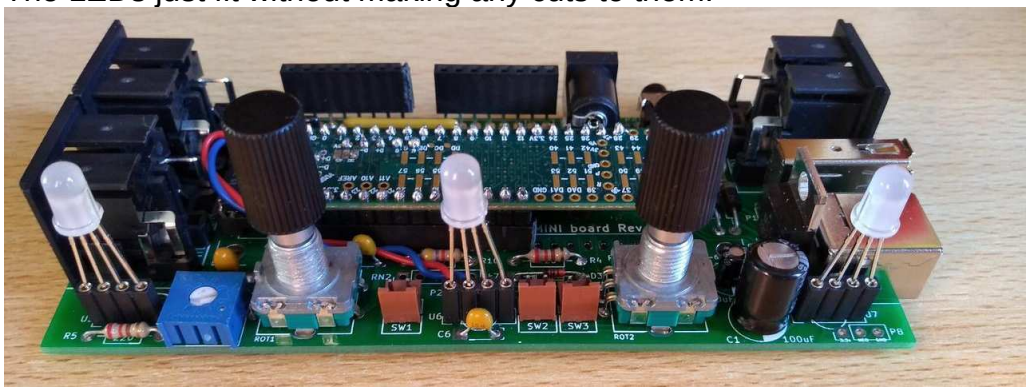


The middle pins are not connected, but that is no problem. The pads on the PCB are not connected either.

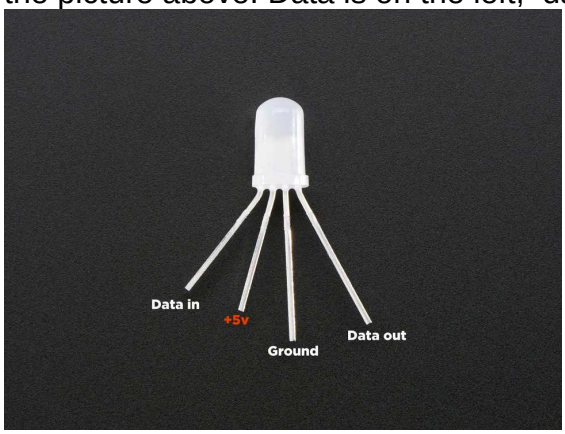
Adding the neopixel displays:
The height of the Neopixel LEDs also has to line up properly with the board, but by chance everything fits beautifully and makes assembly very simple.

First solder in the three female precision four pin headers:

The LEDs just fit without making any cuts to them:

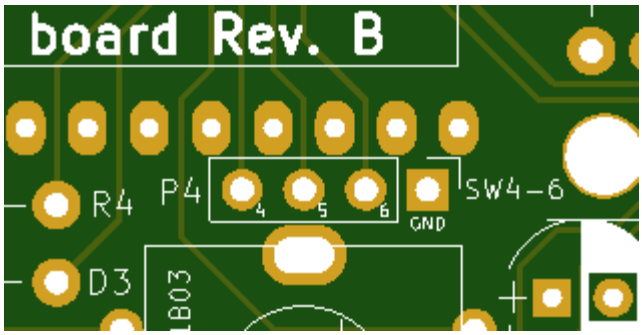


Do watch the pinout of the neopixel LEDs. The longer pins are on the right side in the picture above. Data is on the left, data out on the right side.



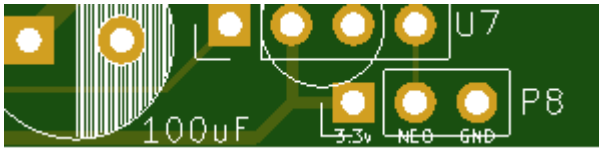
Further modifications

Adding extra switches and LEDs
Just above ROT2 there is an optional connector (P4) for three extra switches.



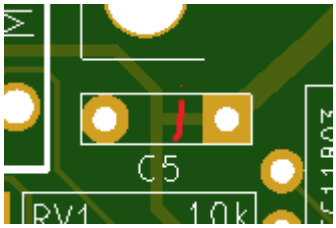
These share a common ground. On the Teensy LC there are not enough available pins to connect any extra pins.

To add extra Neopixel LEDs to these switches, three more LEDs can be daisychained to connector P8.

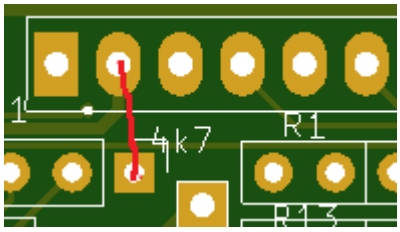


You will need to manually change the firmware to be able to use there extra switches and pins.

Using 3.3V display
If you have a 3.3V display, there is an easy modification to support these. First cut the 5V to the display and RV1, by cutting a trace below C5



Then use a small wire to connect 3.3v power to the display. The picture below shows the wire on the top of the board, but it is easier to do this on the bottom.



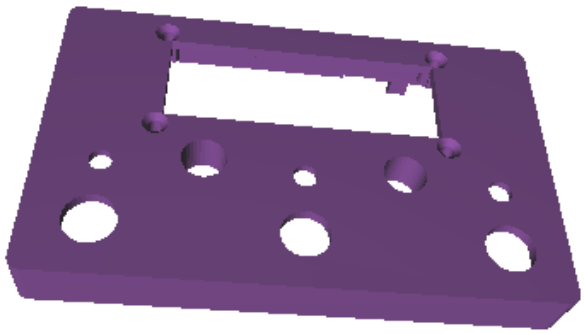
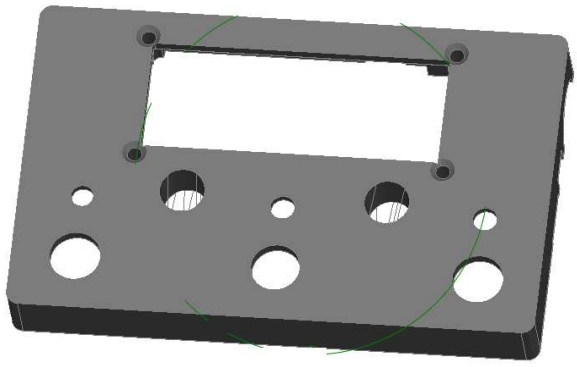
Usually 3.3V displays are more expensive than 5V ones, so unless you have one lying around, there is no reason to do this modification!

Testing:
You can find a link to a hardware test sketch in the firmware section below. Link to sketch:
https://github.com/sixeight7/VController_v3/tree/master/Firmware/Hardware_test_VC_mini_rev_B

Link to pre-compiled test sketch:
https://github.com/sixeight7/VController_v3/tree/master/Firmware/Compiled
you need Hardware_test_VC_mini_rev_B.ino.hex, which can be loaded in the Teensy application.

The test sketch does a number of tests during boot.
Check that the display and the LEDs are working and that the 24LC512 tests out OK.
You can also test the switches and check if the LEDs line up with the switches.

Printing the enclosure
The enclosure consists of two parts, an upper cover and a lower cover. There are two versions of the upper cover: one for the Buydisplay displays and one for the Adafruit (RGB) displays:

Upper cover Buydisplay: Link to stl: https://github.com/sixeight7/VController_v3/ VC-mini hardware/Enclosure/ VCmini_upper_cover_Buydisplay_display.stl	
Upper cover Adafruit: Link to stl: https://github.com/sixeight7/VController_v3/ VC-mini hardware/Enclosure/ VCmini_upper_cover_Adafruit_display.stl	
Lower cover: Link to stl: https://github.com/sixeight7/VController_v3/ VC-mini hardware/Enclosure/ VCmini_lower_cover_b.stl	

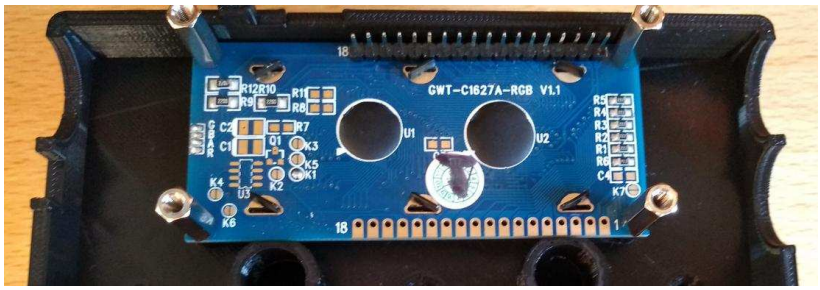
I use Innofil PLA black 2.85 mm on a Ultimaker 3 printer. The print quality setting is “draft”. This will have fewer layers, give a stronger result and reduce printing time. Probably ABS will give a stronger enclosure, but so far I have not experimented with this, as the 3D printer I make use of does not have the correct nozzle for that filament.

Putting it all together

Once the enclosure is ready and all the board has passed the hardware test, it is time to put everything together.

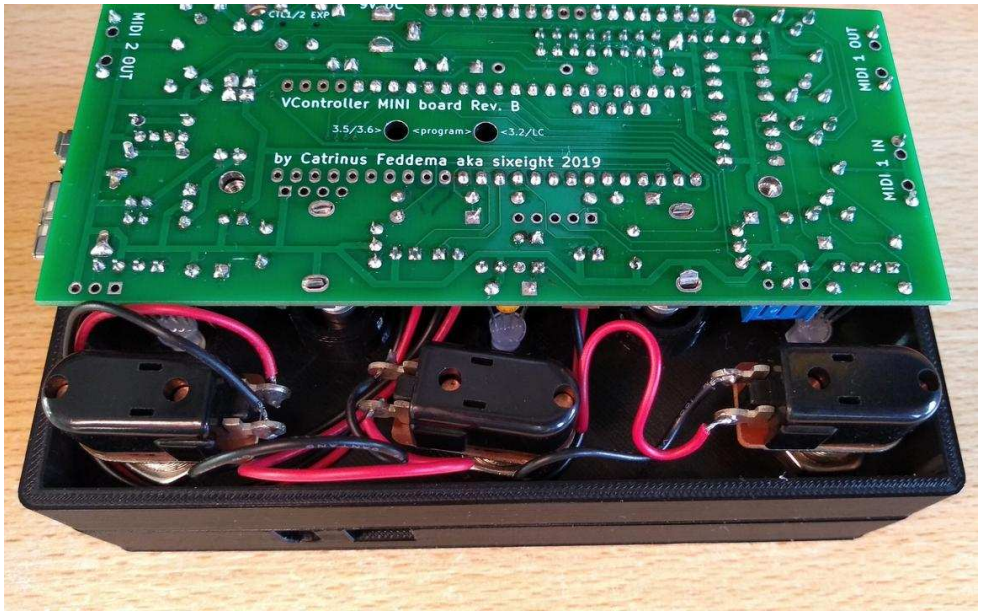
First solder the 2 pcb connection wires to the switches. The default length is a bit long, so I usually cut them in half.

First attach the display to the top half of the enclosure using the screw and the spacers:



Now add the encoders to the PCB. Do not solder them, until the PCB is put in the enclosure and the rotary knobs are aligned with the holes in the enclosure.

Then add the switches:



It should all fit nicely.

Firmware
There are two ways to install firmware. One is to use a pre-compiled hex file. The other way is to compile the data yourself, using the Arduino IDE.

Loading precompiled hex files to the Arduino:

In https://github.com/sixeight7/VController_v3/tree/master/Firmware/Compiled you can download the hex files for the test sketch and the VController firmware itself. Right click on the hex file and select Save as…

To install the firmware on the VController you need the following tool:
https://www.pjrc.com/teensy/loader.html

Follow the instructions on the PJRC website to install the tool for you operating system.

To install the firmware, take the following steps:

1. Connect the VController or just the Teensy to your computer using a USB cable
2. Press the small button on the Teensy. It is now ready to receive firmware.
3. Start the Teensy loader. You should see the following three buttons:

4. Press the first button to open the hex file.
5. Press the second button to upload it to the Teensy.
6. Press the third button to reboot the Teensy. This should reboot the VController with the hardware test sketch or the Vcontroller firmware.

Compile the Teensy sketches yourself:

You will need to install Arduino IDE with the additional Teensyduino add-on:
https://www.arduino.cc/en/main/software
https://www.pjrc.com/teensy/teensyduino.html

You will need the correct LiquidCrystal library, which can be found here:
https://bitbucket.org/fmalpartida/new-liquidcrystal/downloads/LiquidCrystal_V1.2.1.zip

Test sketch for hardware: to test the displays, LEDs and switches:
https://github.com/sixeight7/VController_v3/tree/master/Firmware/Hardware_test_VC_PM

Firmware can be downloaded and installed from github:
https://github.com/sixeight7/VController_v3/tree/master/Firmware/VController_v3

The first page of the VController gives instructions on how to compile the code for the full VController or for the VC-mini. Enable the correct hardware.h file and make the right settings in the Arduino IDE.

```
// **** Choose the correct hardware below and update the Arduino compiler settings ****
// Current version of Arduino: 1.8.9 and TeensyDuino: 1.46

// Hardware of production model
#include "hardware.h"
// Arduino IDE settings: Board: Teensy 3.1/3.2, USB Type: MIDI, CPU speed: 96 MHz, Optimize: Faster, Programmer: AVRISP mkII

// Hardware of VC-mini rev. B
//#include "hardware_VCmini_b.h"
// Arduino IDE settings: Board: Teensy 3.6, USB Type: MIDI, CPU speed: 180 MHz, Optimize: Fast(!), Programmer: AVRISP mkII
```

How much time does it cost to build a VC-mini:

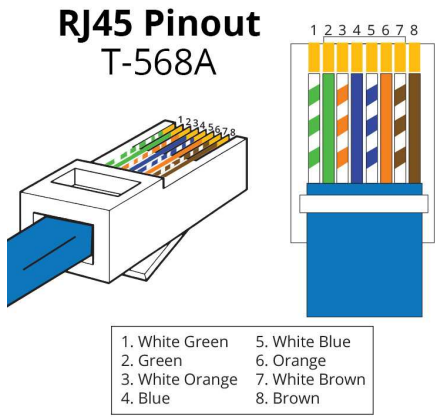
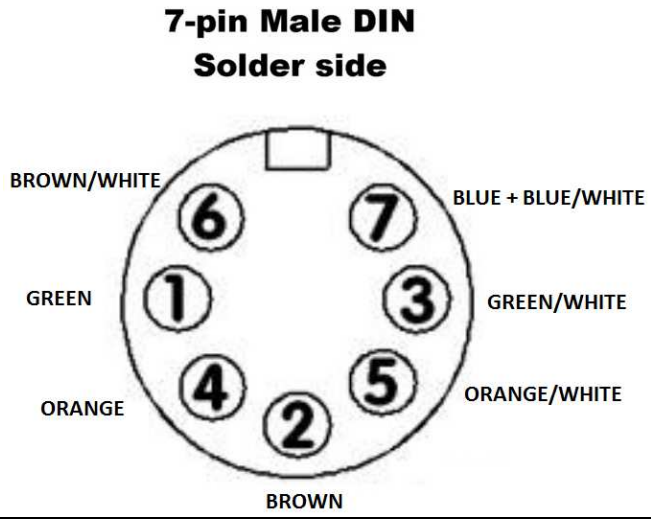
Ordering of parts	1 hours
Having enclosure and 3D printing done	15 minutes
Building PCB	2 hours
Putting it all together	15 minutes
Testing and debugging	30 minutes
Total time:	**4 hours**

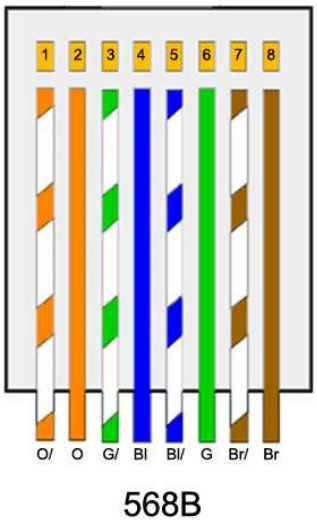
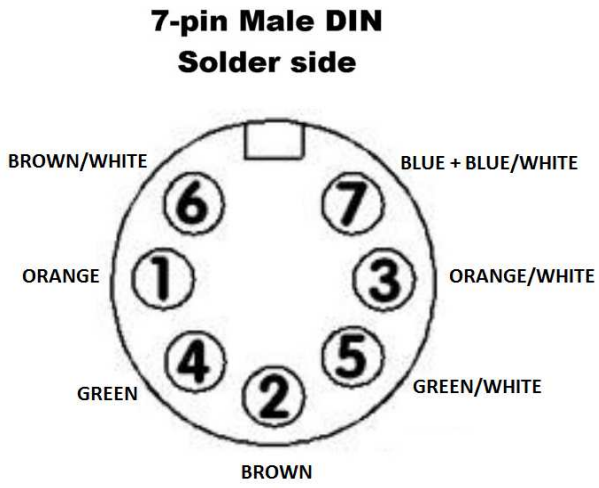
RRC2 cable:

To make an RRC2 to DIN-7 cable, I use an existing CAT 5 or CAT6 cable and replace one of the RJ45 connectors with a DIN-7 plug.

First check if the existing cable has been wired according to T-568A or T-568B standard, by checking if the colours match the correct diagram below. Then use the correct diagram for the DIN-7 side.

The view of the DIN-7 pin is the solder side of the plug.

RJ45 side – T-568A	DIN-7 side
	

RJ45 side – T568B	DIN-7 side
	

Additional information:
Check out my blog at vguitarforums.com:
http://www.vguitarforums.com/smf/index.php?topic=15154.0

I have spent countless hours since May 2015 developing the VController and the VC-mini. I would really appreciate a small donation:
https://www.paypal.me/sixeight