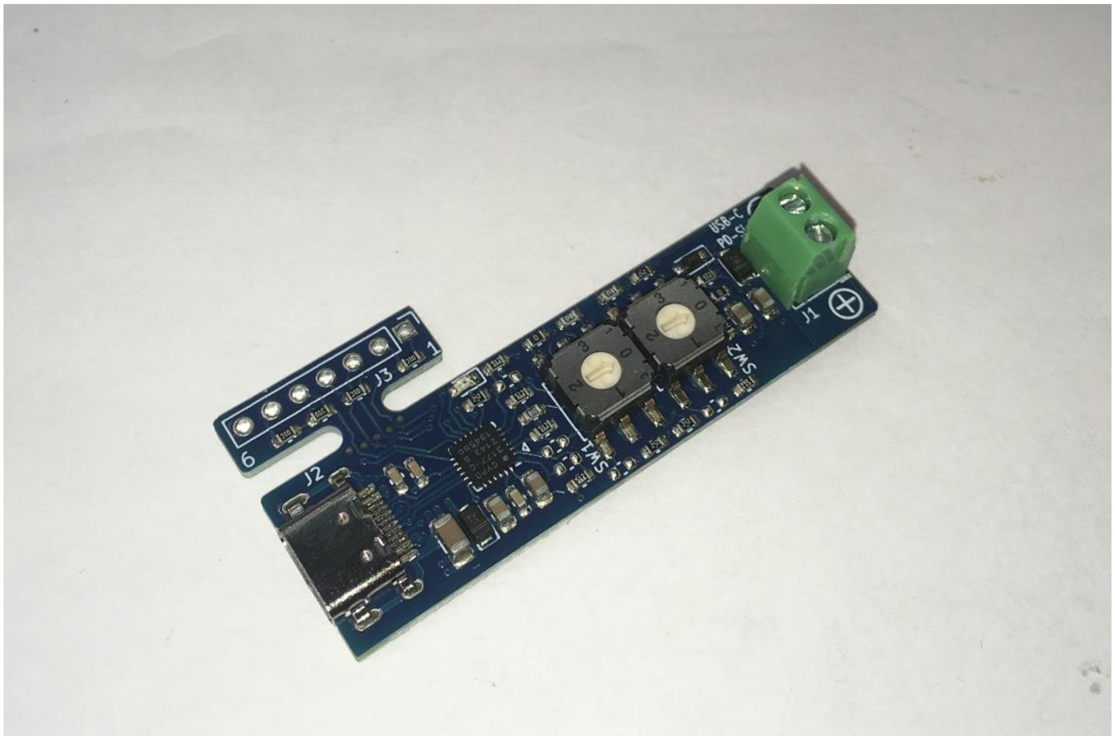

P42 USB-C Power Sink

BCR (Barrel Connector Replacement)

Rev 5

Designed by Pier42 Electronics Design

Wolfgang Friedrich

https://www.tindie.com/stores/pier42/

https://hackaday.io/project/168762-usb-c-power-delivery-sink-bcr

https://github.com/wolfgangfriedrich/

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Introduction

USB-C PD offers the option to negotiate power delivery from a compatible power supply. This board plays the role of a sink device, enabling any device to be powered from a USB power supply. Any type of power connector can be attached through a 2-pin screw terminal or directly soldered into the PCB for a lower profile.

The voltage can be set to 5V, 9V, 15V (12V with solder bridge), or 20V and the current can be set to 1A, 2A, 3A, or 5A. This board has new FETs, which have a Rds_on of only 6.9 mOhm measured. This reduces the dissipation even more compared to the previous version and keeps the board cooler, even with 5 A current draw. Also new in this latest revision are 2 TVS diodes on the input and output for over voltage and surge protection.

BCR stands for Barrel Connector Replacement, the term is invented by Cypress, the manufacturer of the controller chip in use here.

This board has the goal to replace random power adapters with a standardized way to use a USB-C power delivery (USB PD) adapter instead. For regular operation, no programming or software configuration is involved with this design. All options are set through resistor values.

This is a set and forget device. Set your current and voltage needs before plugging the device to your USB-PD source and enjoy the power at the output. This is **not** a power supply to change voltage and current during operation.

If needed, an I2C interface to a microcontroller is available, to access status and control registers. This part of the board is separated through a break-off tab (mouse bites) and can be snapped off.

I made the conscious design decision to not add a USB-A connector option at the output end. I did not want to build a device, that is capable of putting more than 5V on the VBUS pin of a regular USB cable and potentially destroy the device that is plugged in.

All Features:

- USB-C PD Power Delivery Sink
- Selector switch for 5V, 9V, 15V (12V with solder bridge), or 20V
- Selector switch for 1A, 2A, 3A, or 5A
- Max current 5A, settable in 250mA steps through resistor options.
- Red LED to indicate failed power request
- I2C telemetry interface to controller chip
- Snap off option for telemetry interface
- For fixed voltage and current, the switches can be replaced by wire jumper
- small form factor to be heat shrinked as part of the power cable
- Size 53mm x 15.4mm (without telemetry interface)
- Height 12mm with screw terminal and switch, 6mm without
- 3" (7.5cm) heatshrink tube for protected installation
- 2oz copper to safely handle 5A
- Lead free RoHS compliant

Hardware

The USB-C PD Sink is designed as small as possible to be assembled in-line with the power cord that is going to be upgraded to USB-C. Alternatively it can be connected to a microcontroller through I2C and some IOs to access telemetry configuration and status.

I2C address

The I2C address of the chip is 0x08 (7-bit format).

All registers and communication is described in ‘Cypress EZ-PD™ BCR Host Processor Interface Specification Doc. No. 002-26784’ and it is somewhat tricky.

Host Port Interface

Pin Nr	Name	IO	Description
1	Vcc	Power	+3.3V, only to be used as an indication that the BCR is running, not to power any devices.
2	INT	IO	Interrupt, active low with 10K Ohm pull-up.
3	GPIO	IO	General purpose Input or Output
4	FLIP	IO	Indicates orientation of USB-C jack with 10K Ohm pull-up.
5	SDA	I2C	I2C Data line with 10K Ohm pull-up.
6	SCL	I2C	I2C Clock line with 10K Ohm pull-up.
7	GND	Power	Ground return

Table 1: Host Port Interface Pins

Voltage and Current Select

The device is either preconfigured with 2 resistors setting a fixed voltage and current or adjustable with 2 rotary switches. The maximum voltage is selectable by the rotary switch S1 to be 5V, 9V, 15V (12V with JP1 closed), or 20V. The minimum voltage is set to 5V, but could be changed by mounting resistors according to Table 3. The current is selectable by the rotary S2 switch to be 1A, 2A, 3A, or 5A. Do **NOT** change the switches during operation. This is a set and forget device. Set your current and voltage needs before plugging the device to your USB-PD source and enjoy the power at the output. This is **not** a power supply to change voltage and current during operation.

A table on the bottom side of the board shows the mapping of the switch positions to the selected voltage/current.

All values can be adjusted by changing the respective resistors according to the 4 tables below. An assembly drawing to locate the resistors is appended as well.

Voltage requested [V]	Pull-up resistor R10 [Ohm]	Pull-down resistor - selected through rotary switch [Ohm]
5	open	0 (**R15**) – S1 pos0
9	5.1 k	1 k (**R16**) – S1 pos1
12	5.1 k	2.4 k (**R17**)+ JP1 closed – S1 pos2
15	5.1 k	4.8 k (**R17+R25**)+ JP1 open – S1 pos2
19	5.1 k	10 k - not implemented
20	5.1 k	open (**R19**) – S1 pos3

Table 2: Maximum Voltage Select Resistors

Voltage requested [V]	Pull-up resistor R7 [Ohm]	Pull-down resistor R12 [Ohm]
5	open	5.1 k - actual setting
9	5.1 k	1 k
12	5.1 k	2.4 k
15	5.1 k	5.1 k
19	5.1 k	10 k
20	5.1 k	open

Table 3: Minimum Voltage Select Resistors

It is also possible to set the min and max voltage to the same value to force exactly this one voltage to be the only valid output. For that R7 and R12 need to be not populated and R11 to be populated with a 0 Ohm resistor.

Current set [A]	Pull-up resistor R8 [Ohm]	Pull-down resistor R13 [Ohm]
0	open	0
1	5.1 k	1 k – S2 pos0
2	5.1 k	2.4 k – S2 pos1
3	5.1 k	5.1 k – S2 pos2
4	5.1 k	10 k
5	5.1 k	open – S2 pos3

Table 4: Coarse Current Select Resistors

Current set [A]	Pull-up resistor R8 [Ohm]	Pull-down resistor R13 [Ohm]
+0	open	5.1 k - actual setting
+250	5.1 k	1 k
+500	5.1 k	2.4 k
+750	5.1 k	5.1 k
+900	5.1 k	open

Table 5: Fine Current Select Resistors

The following image shows locations for setting a fixed voltage on a board without the rotary switches. Any resistor value between 0 Ω and 100 Ω works fine.

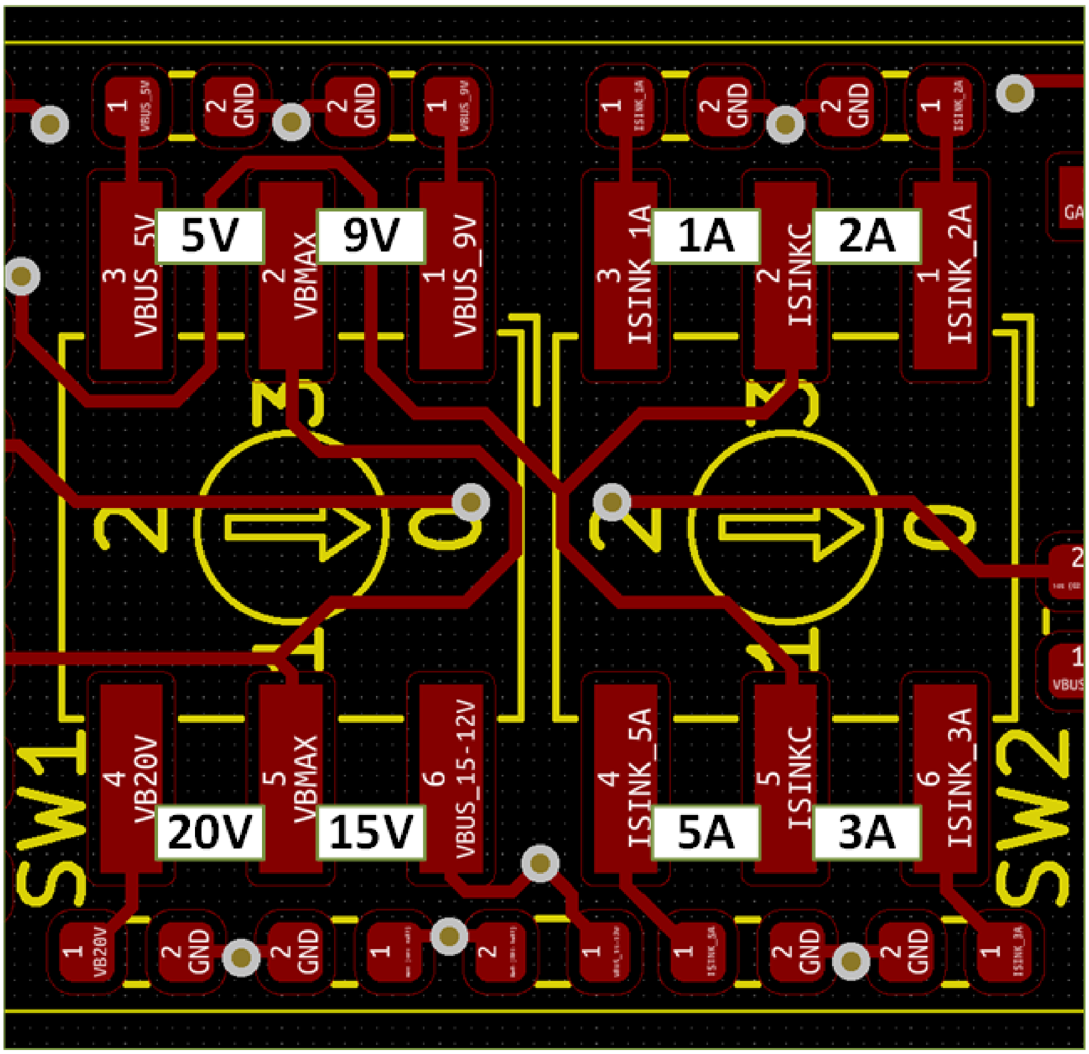

Figure 1: Fixed resistor locations for voltage and current setting

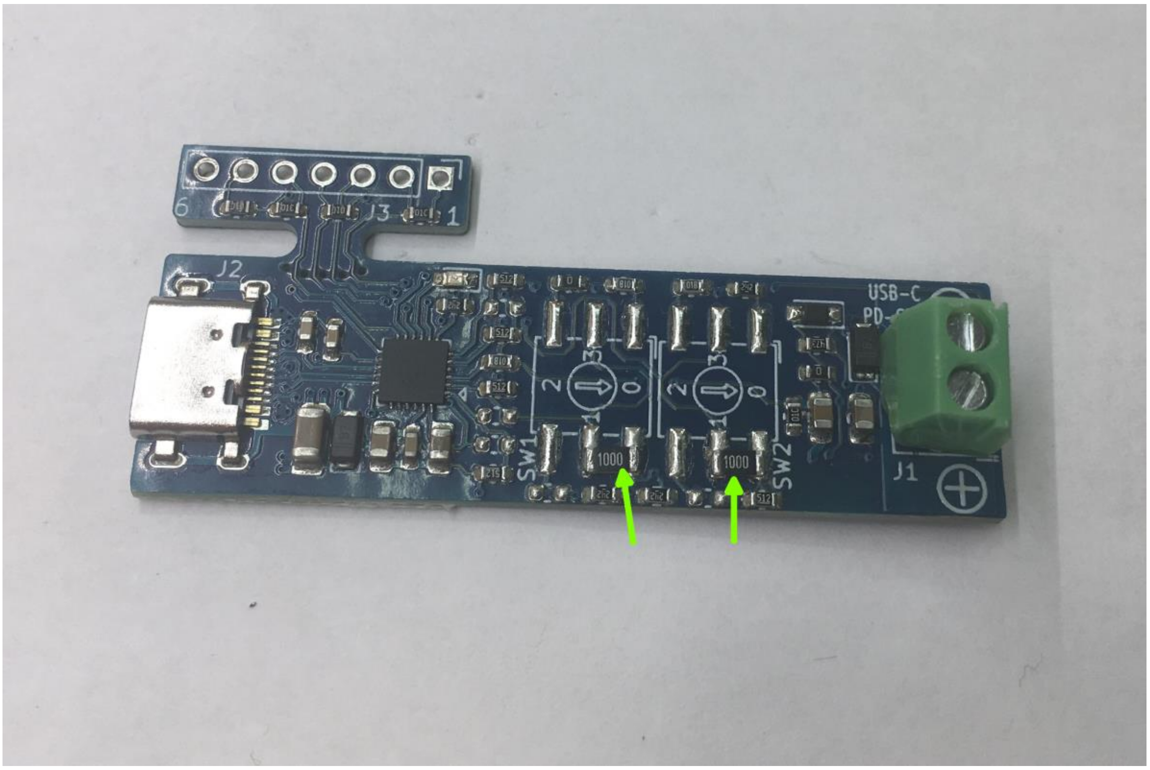

Figure 2: Image of a fixed voltage and current board set to 15 V, 3 A

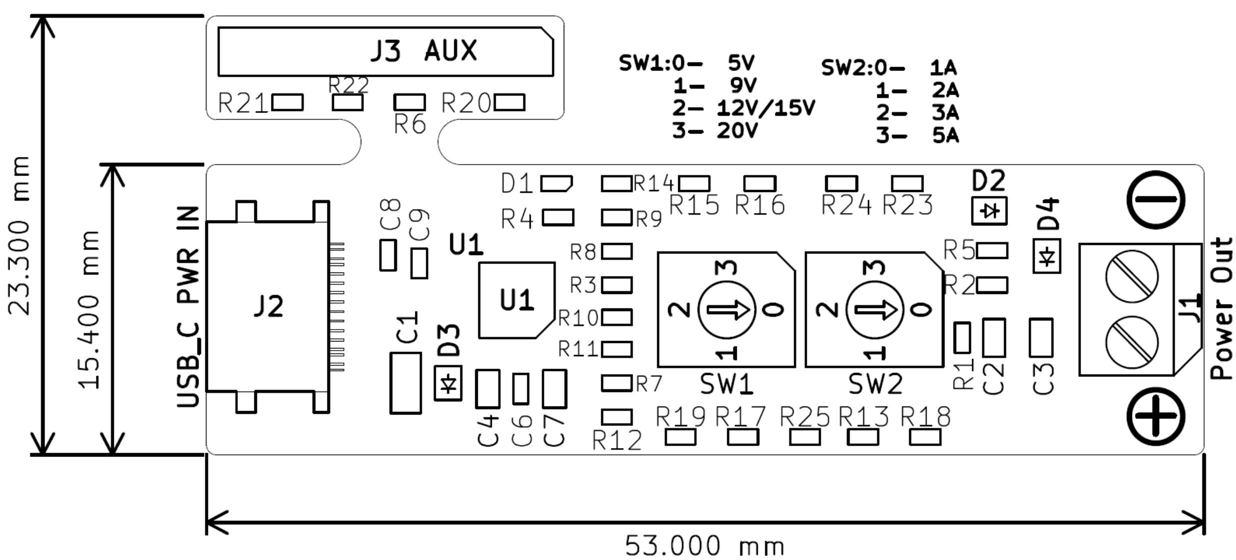

Figure 3: Rev 5 Assembly Drawing Top side with component designators

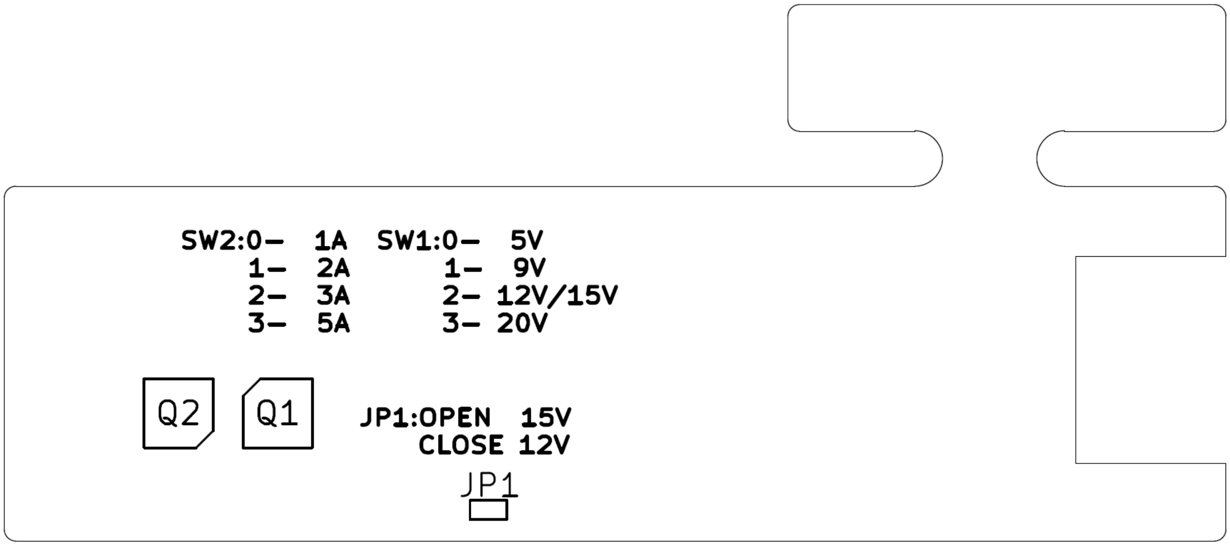

Figure 4: Rev 5 Assembly Drawing Bottom side with component designators

Normally the board is going to request 15 V from the PD source when S1 is in position 2. When solder jumper JP1 is bridged with a 0 Ω resistor or solder bridge the voltage setting changes to 12 V. 15 V is one of the regular fixed voltage settings in the USB PD specification, but as 12 V is also a very popular voltage, the option for 12 V is given. The PD power supply must be able to supply 12 V as source voltage to make this option happen.

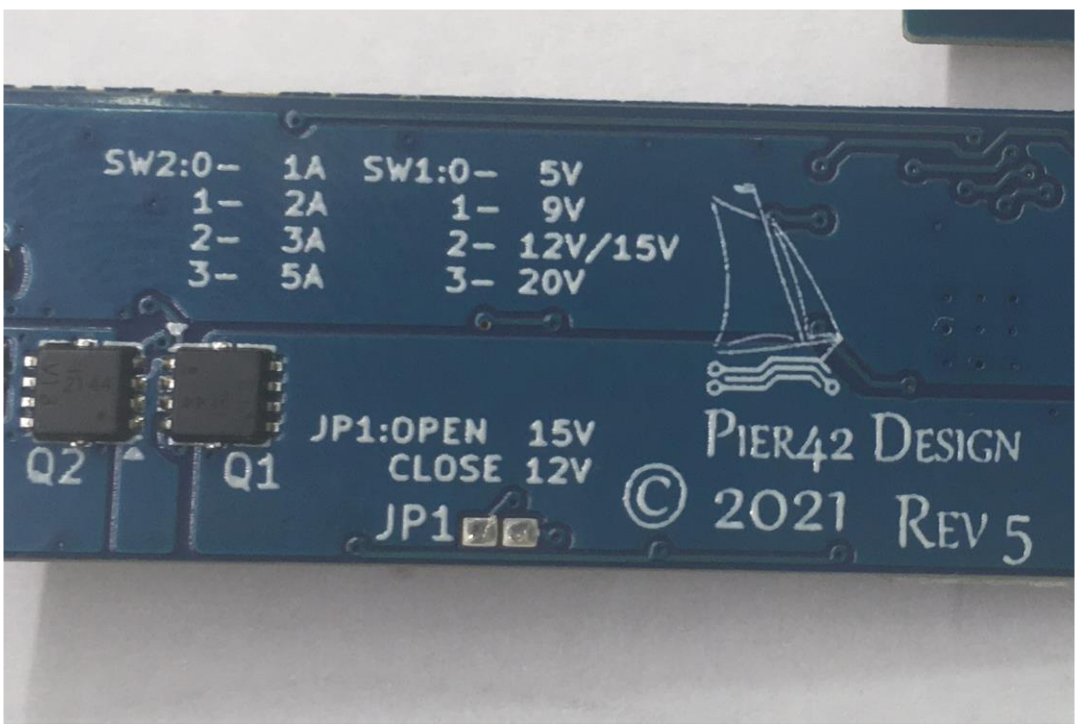

Figure 5: Image of JP1 location with the solder bridge open

Software

Everything is selected through resistors and the switches, no software required. Please move along, nothing to see here.

Telemetry

I managed to talk to the BCR over the I2C interface, which is not quite straight forward, as the chip adds a mandatory 3 to 5 cycle clock stretch. My solution so far is a bus pirate set to I2C 5 kHz clock speed. With those commands I am able to read out ID and status registers, even though the response does not match the datasheet for the IDs.

List of Bus Pirate commands to read registers 0x0000, 0x0002, 0x100D, 0x1008:

```
[0x10 0x00 0x00[0x11r]
[0x10 0x02 0x00[0x11rr]
[0x10 0x0D 0x10[0x11r]
[0x10 0x08 0x10[0x11r:4]
```

The telemetry connector can be removed by snapping it off along the break-off tab. For a populated board I would recommend to score a line along the holes on both sides first to put a little less stress on the components nearby.

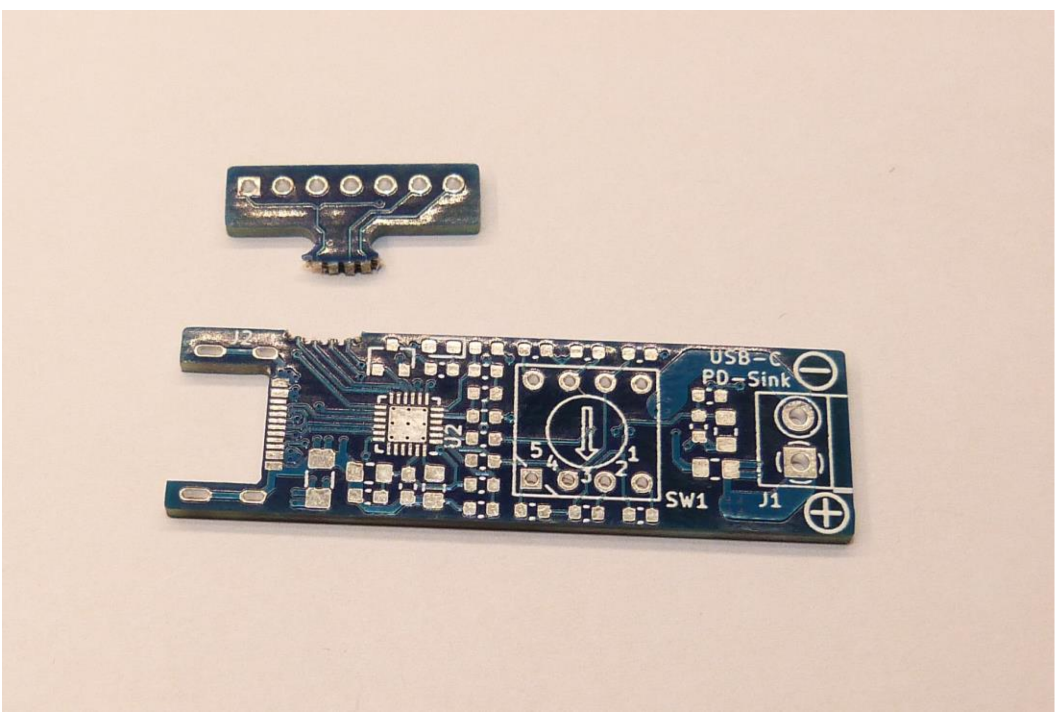

Figure 6: Break-off tab demo on a not populated board.

Heat Shrink

To protect the board and circuit in a permanent setup, the board can be encased in the supplied heatshrink tube. For added strain relieve put more heatshrink on your wire before screwing it down in the terminal block, see Figure 10!

Figure 7: Start heatshrinking at the USB-C connector end.

Figure 8: Work the hot air along the tube from the USB connector to the wire end.

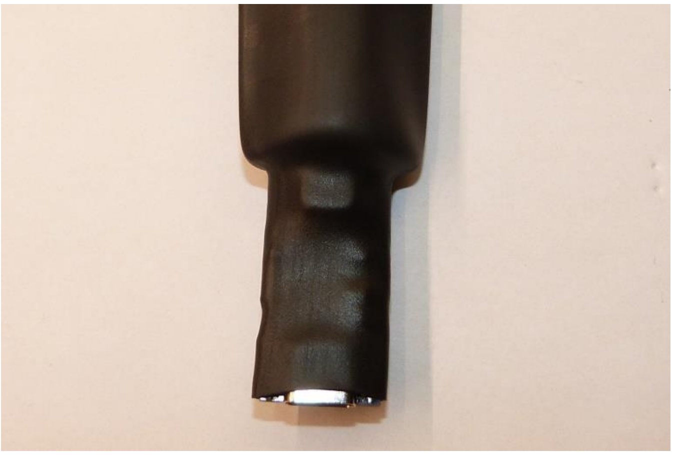

Figure 9: Keep going.

Figure 10: To add more strain relieve, add thinner heatshrink on the wire before inserting into the terminal block.

Figure 11: Finish shrinking at the cable end.

Figure 12: If you forgot to set the switches or want to change them, the topography of the heatshrinked board lets you pick cutouts for the switches or terminal block easily.

This is a living document. Any missing content will be added as required.

Revision Control

Version	Data	Changes
1.0	23. April 2022	Rev 5 Madman Chicken-Scratch Manifesto