Project Documentation

C64 PSU global

Project number: 133

Revision: 1

Date: 18.02.2020

Disclaimer

Working with mains voltages can be harmful and cause death. Do not connect this PCB to mains (230VAC) unless you are trained in doing so and know the required safety regulations.

This PSU is a prototype, it is not certified in any way and might only be used as a prototype under laboratory conditions. Usage is at own risk. Do not leave unattended while powered on.

The PSU is designed to be installed in a plastic case. In case a metal case is used, a 3 prong mains connector is required and the case has to be connected to PE in a suitable way.

The documentation is drafted to the best of my knowledge. The creator is not liable for the accuracy and completeness.

C64 PSU Global Rev. 1

Module Description

Introduction

The C64 PSU Global is a replacement power supply for the Commodore C64, which is suitable to power the Commodore computer from 115V and 230V.

There are two options for transformers for the 9VAC, one is capable of being switch between 115V and 230V.

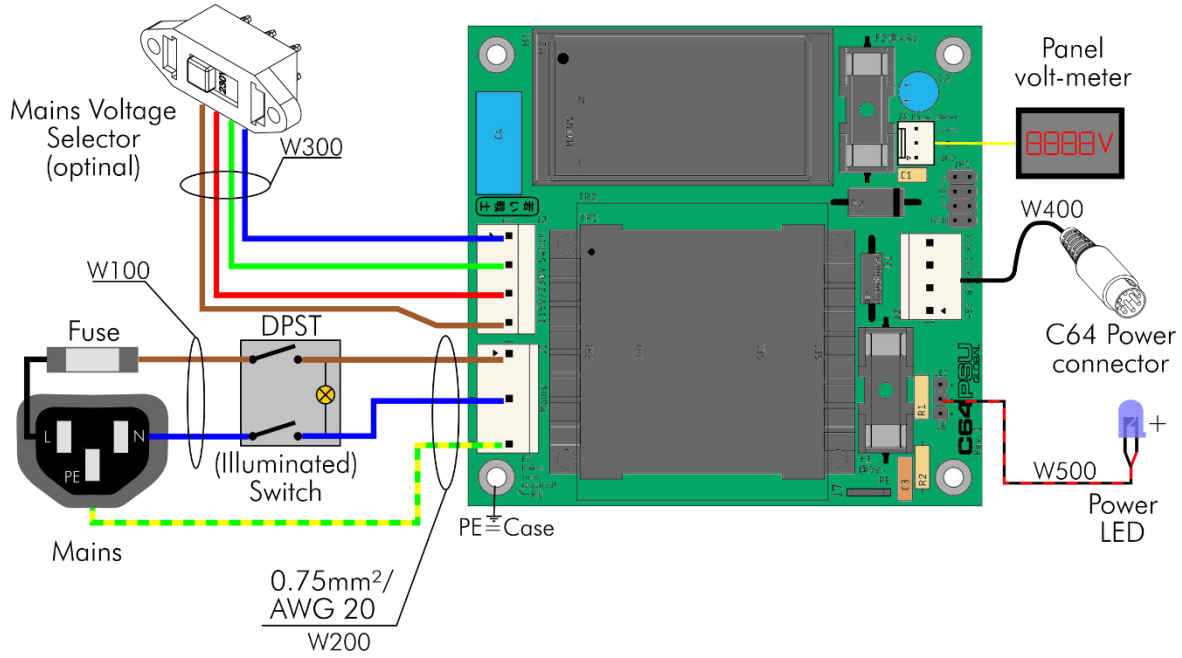


Figure 1: Block diagram

The 5VDC are generated by an AC/DC converter. There are two options that can be placed on the PCB, both have a wide range input (85VAC-264VAC) and are suitable for both main voltages without switching. The technical data of the power supply vary, depending on the chosen options:

Option	Type	Mains	Output
Transformer TR1	Hahn BV UI 304 0153	115VAC/230VAC	9VAC/1.1A
Transformer TR2	BREVE TUFVASSONS TEZ10/D230/9V	230VAC	9VAC/1.1A
AC/DC M1	RECOM RAC10-05SK/277	85VAC-305VAC	5VDC/2A
AC/DC M2	Mean Well MPM-10-5	80VAC-264VAC	5VDC/2A

The mains voltage selector switch is only required for the option Transformer TR1. A fuse for the mains is external and mandatory. It is recommended to use a combination of mains with an integrated fuse and maybe a switch. The switch should switch off both, the life and the neutral mains. In Figure 1, an illuminated mains switch is shown. Its lamp is located at the switched side. A not illuminated switch is recommended for the 115V/230V version, since the light of a 230V switch is pretty dim at 115V.

A power LED can be connected. At least one signal should allow the use to notice, whether the PSU is switched on or off, the Power LED or the illuminated mains switch.

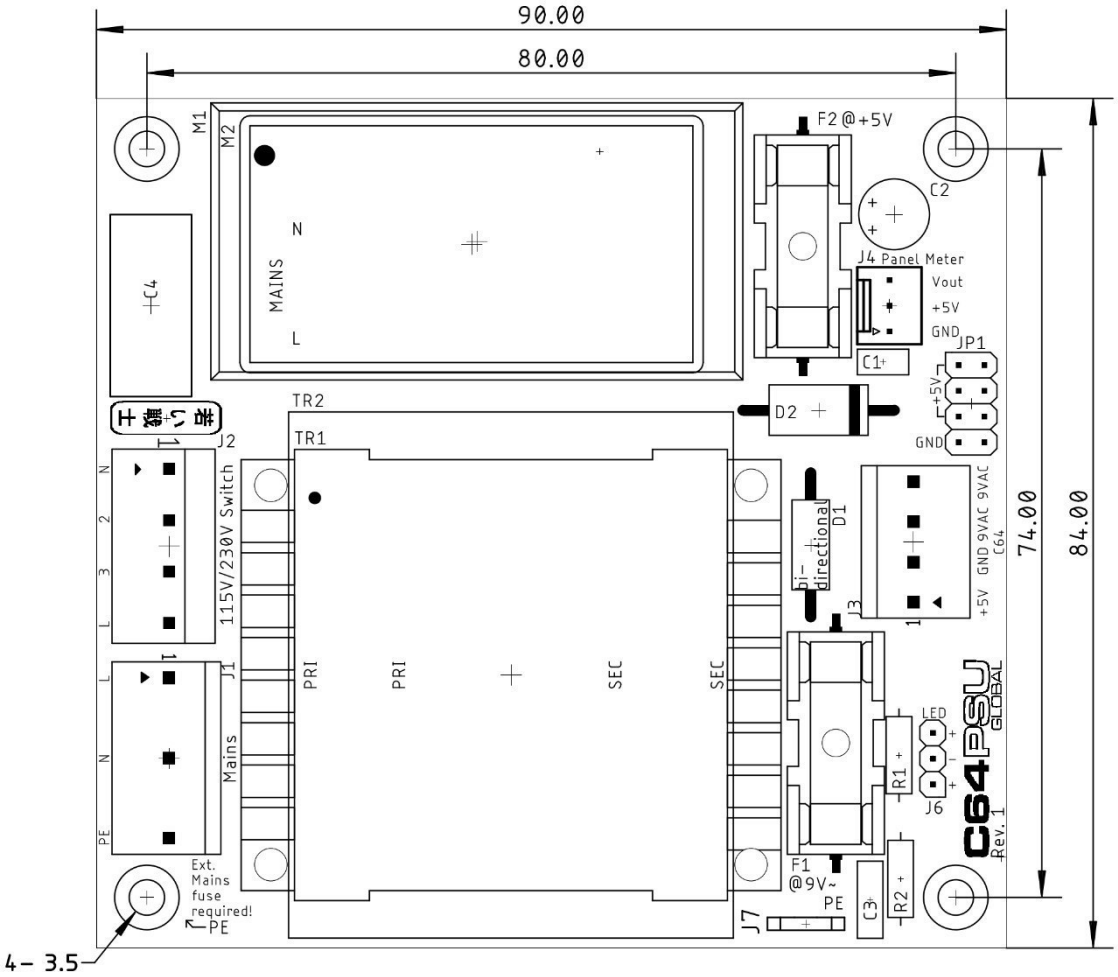


Figure 2: Dimensions

A panel meter can be connected. The common panel meter measures the current in the negative (ground) lead. The panel meters might be very inaccurate and the current and voltage should be adjusted with a load resistor and a multimeter. Sometimes, it is not even possible to adjust the current properly, so the panel meter is not really recommended. In case the panel meter is not installed, JP2 has to be bridged with jumpers.

A not yet developed over voltage protector (aka C64 saver) can be connected to JP1. In case this is not installed, JP1 has to be bridged with jumpers.

An R/C combination (R2/C3) between GND and PE serves for creating System Ground, which is tied to protective earth (PE). Some further power supplies for the monitor or the S-Video/HDMI converters might inject (a weak) mains voltage into the system. This happens due to a capacitive coupling to mains within those PSUs and could be felt when touching the C64 ports.

Connectors

J1 – Mains connectors

- Molex KK 396 Header, Vertical, Friction Lock, 5 Circuits, Tin (Sn) Plating (Pin 2 and pin 4 removed): P/N 0026604050
- KK 3.96mm Crimp Terminal Housing, Friction Ramp, 5 Circuits, Natural: P/N 09503051
- KK 396 Crimp Terminal 2478, 18-24 AWG, Bag, Brass Tin (Sn): P/N 08500106.

Pin	Signal
1	L (hot)
3	N (neutral)
5	PE (protective earth)

J2 – Mains Voltage Selector

This is an option and only required, if the TR1 (the 115V/230V type) is used.

- Molex 5.08mm Pitch SPOX Wire-to-Board Header, Vertical, with Friction Lock, 4 Circuits, P/N 10321041
- Molex 5.08mm Pitch SPOX Crimp Terminal Housing, 4 Circuits, P/N 10013046
- Molex SPOX Crimp Terminal, 18-24 AWG, Brass, P/N 08701031

As a switch, the type Bulgin T22205B436B is suggested.

J3 – C64 Power Connector

- Molex KK 396 Header, Vertical, Friction Lock, 4 Circuits, Tin (Sn) Plating: P/N 0026604040
- KK 3.96mm Crimp Terminal Housing, Friction Ramp, 4 Circuits, Natural: P/N 09503041
- KK 396 Crimp Terminal 2478, 18-24 AWG, Bag, Brass Tin (Sn): P/N 08500106.

Pin	Signal
1	+5V
2	GND
3	9VAC2
4	9VAC1

J4 – Panel Volt-Meter

- Molex KK 254 Wire-to-Board Header, Vertical, with Friction Lock, 3 Circuits, Tin (Sn) Plating: P/N 22272031
- KK 254 Crimp Housing, 3 Circuits, Natural: P/N 22-01-3037
- KK 254 Crimp Terminal, 22-30 AWG, Bag, Hot Tin (Sn) Dip Plating: P/N 08500114

Pin	Signal
1	GND
2	+5V (supply)
3	+5V (measurement)

Power LED – J6

- Pin header, 1x3 circuits, 2.54mm (0.1") pitch
- Crimp housing: Dupont crimp housing
- Dupont crimp terminals

It is possible to use a widely available (Ebay, AliExpress etc.) Dupont cable, which can be cut and soldered to the LED.

Pin	Signal
1	LED +
2	LED -
3	LED +

J7 – PE Connection

The PE connection to the chassis is accomplished via the mounting hole marked with "← PE". This is directly connected to the mains connector J1, Pin 5. In case other metal parts have to be grounded, a 6.3 x 0.8 FastOn (spade) connector can be installed in J7.

Jumpers

JP1 – Over-Voltage Protection

In case an over-voltage protection is not installed, the pin header JP1 should be bridged (3x Input 5V ↔Output 5V). The jumpers should be rated 1A or more.

Signal	Pin	Pin	Signal
Input 5V	1	2	Output 5V
Input 5V	3	4	Output 5V
Input 5V	5	6	Output 5V
GND	7	8	GND

Wiring

Introduction

This device is connected to mains. Mains voltage is potentially lethal. High currents, that can occur in this device can cause fire hazards. Do not carry out this work, if you are not trained!

Up to four sorts of crimp contacts are required for installing this device:

- Molex SPOX/KK 3.96 (J1, J3, J5)
- Molex SPOX/5.08 (J2, option 230V/115V)
- Dupont 2.54mm

A crimp tool for the other types of connector is the Engineer PA-20. A cheaper, but less good tool is the IWISS IWS-2820M. It is also possible to crimp the terminals with the SN-28B tool. Please refer to the Cable Making Guide on my website: http://tech.guitarsite.de/cable_making.html

The mains should be wired with 0.5mm²/AWG21 to 0.75mm²/AWG20 cables. It might be a good idea to salvage a piece (30cm) of mains cable, this will provide the proper cable colors for wiring up the mains connector, switch and mains voltage selector switch.

The colors for the mains cables are different, depending on the country. They can be found here:

https://en.wikipedia.org/wiki/Electrical_wiring

Mains Connection	EU/UK/Australia	North America
Live/hot	brown	black
Neutral	blue	white
Protective Earth (PE)	yellow/green	green or yellow/green

The cable colors should be according to the regulations of the respective country.

The lengths are calculated for the 3D printed case, which is provided with this project. It can vary, if a different case is used.

The Mains Cable (W100)

This cable connects the appliance inlet with the mains switch (Live and Neutral). It is referenced with "W100".

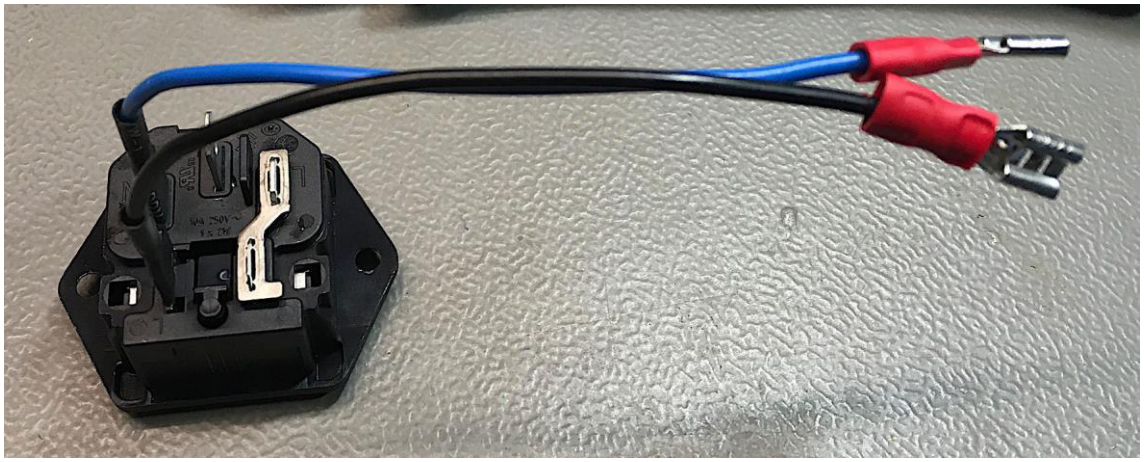


Figure 3: Mains cable (inlet) – W100

Signal	Color	Length	Connects to	Terminal
Live/hot	Brown*	11cm	Switch/input (live)	FastOn 4.8x0.8
Neutral	Blue*	11cm	Switch/input (neutral)	FastOn 4.8x0.8

* Colors according to the local regulations (see above)

Appliance inlet: Schurter 6200.2300

The cables are directly soldered to the spade connectors and covered with a short piece of shrinkable sleeve (Figure 3).

The PCB Mains Cable (W200)

This cable connects the PCB (J1) to the mains switch and the PE of the mains connector. It is referenced by "W200".

Signal	Color	Length	Connects to	Terminal
Live/hot	Brown*	11cm	Switch/output (life)	FastOn 4.8x0.8
Neutral	Blue*	11cm	Switch/output (neutral)	FastOn 4.8x0.8
Protective Earth	Yellow/green*	8cm	Mains connector (PE)	FastOn 6.3x0.8

* Colors according to the local regulations (see above)

Crimp housing: Molex 09503051

Crimp terminals (3 ea): Molex 08500106

Faston 6.3x0.8 for PE

Faston 4.8x0.8 (2 ea) for L and N

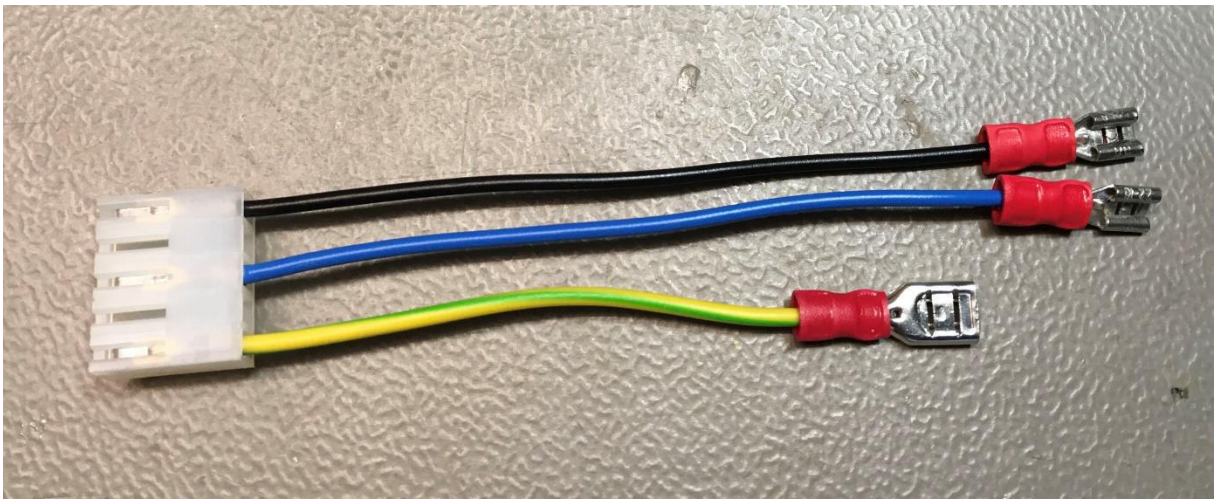


Figure 4: PCB Mains cable – W200

The Mains Voltage Selector Cable – W300

This cable connects the switch for selecting the mains voltage to the PCB (J2). It is further referred to as "W300". **W300 is optional** and only required for the 230V/115V version.

Figure 5: Voltage Selector Cable - W300

W300 has to be wired like shown in Figure 6. The wiring should be checked with a multimeter before the PSU Global is powered up. A failure can ruin the PSU.

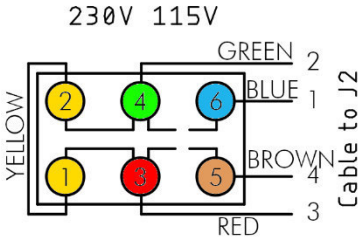


Figure 6: Wiring of the mains voltage selector switch

Position	Connected	Open
230V	Pin 2 – 3	Pin 4 – 3, Pin 1 – 2, Pin 1 – 4
115V	Pin 3 – 4, Pin 2 – 1	Pin 2 – 3, Pin 1 – 4

Table 1: Mains Voltage Selector checks

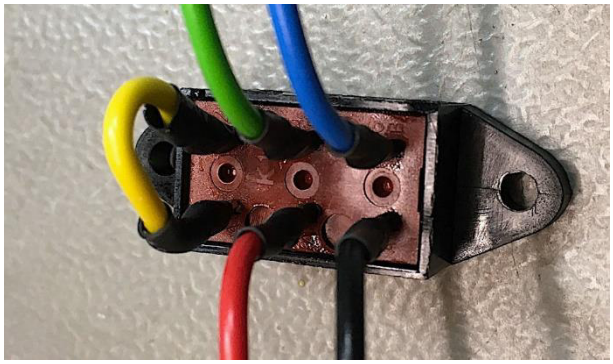


Figure 7: Mains voltage selector switch

Figure 7 shows the details of the mains voltage selector switch.

Pin (switch)	Signal	color	Length	Pin (J2, PCB)
1	Primary Coil Series	Yellow**	4cm	-
2	Primary Coil Series	Yellow**	-	-
3	PR2A	red**	8cm	3
4	PR1B	Green**	8cm	2
5	Live	Brown*	8cm	4 (L)
6	Neutral	Blue*	8cm	1 (N)

* Colors according to the local regulations (see above)

** Chose colors, so they do not interfere with the regulations mentioned before.

Material:

- Voltage selector switch: Bulgin T22205B436B
- Crimp housing: Molex 10321041
- 4 crimp terminals: Molex 08701031
- Shrinkable sleeve
- Cable, 5 colors

An alternative for the crimp terminals and the housing is

- Crimp housing: Adam Tech MTF-B-04 (tme.eu)
- Crimp terminal: Adam Tech MTF-B-C-01-R (tme.eu)

The Adam Tech terminals do not fit into the Molex housing and vice versa. The Adam Tech crimp housing fits on the Molex connector on the PCB.

I have also found replacements on AliExpress:
https://www.aliexpress.com/item/33023034171.html

Power Output Cable – W400

The installation of the PSU in a metal enclosure requires connection to PE of all metal parts of this enclosure. These connections need to be proved (at least with a multimeter) after finishing the assembly. One mounting hole of the PCB is connected to the PE of the installation. This is marked "← PE". Chopper disks are recommended to attain a good connection.

In case, the power cables should stay connected to this PSU, strain reliefs are required. An alternative way is a DIN-jack on the back panel of the power supply and extra cables to have as few cables in the installation as possible.

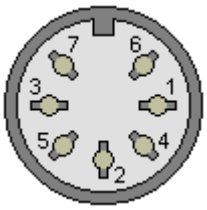
C64 Power Jack	Pin	Voltage	J3
	1	-	-
	2	GND	2
	3	-	-
	4	-	-
	5	+5V	1
	6	9VAC(1)	3
	7	9VAC(2)	4

Table 2: Power jack of the C64

Table 2 shows the power jack of the C64. The view is on the particular contact side. This is identical with the view on the solder side of the respective DIN plugs. The cables soldered to the din plugs should be 0.5mm²/AWG21 (LiYY 4x0.5mm²). It is possible to use 0.75mm²/AWG20 wires, but this might require to clip off some of the wire strands, since the solder cups of the DIN plugs are usually not capable of accepting a wire of this diameter. The outer diameter of the power cable has to be 5.5mm.

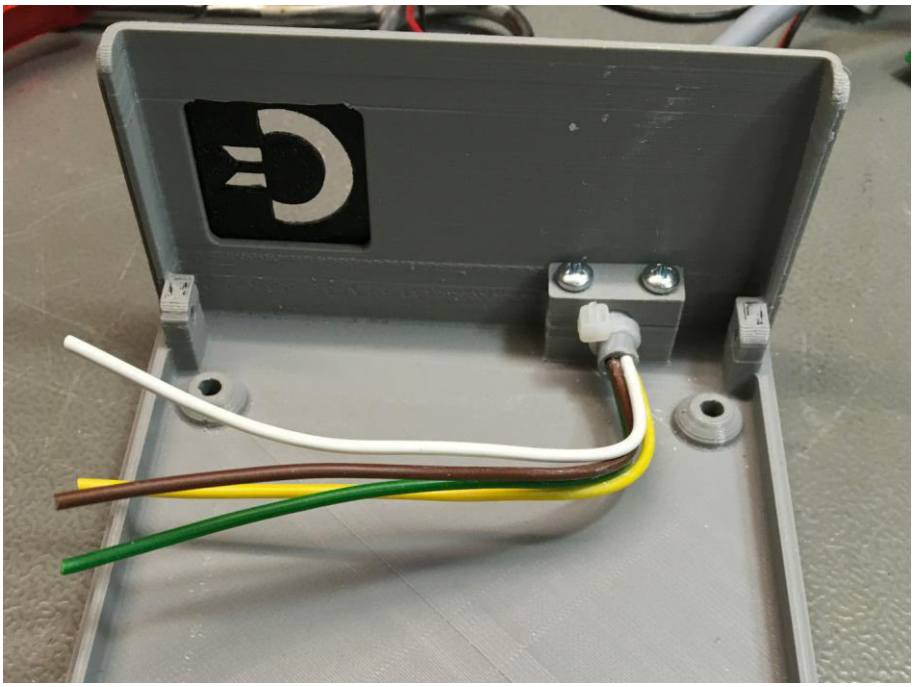


Figure 8: Installing the power cable

Figure 8 shows the end of the power cable, that ends inside the case. The outer insulation was stripped off about 10cm. The cable is secured with the strain relief and an additional cable tie. It is possible to crimp the cable outside the case and insert the cables with the crimp connector one by one, but the recommended way is to install the cable in the case and then crimp it.

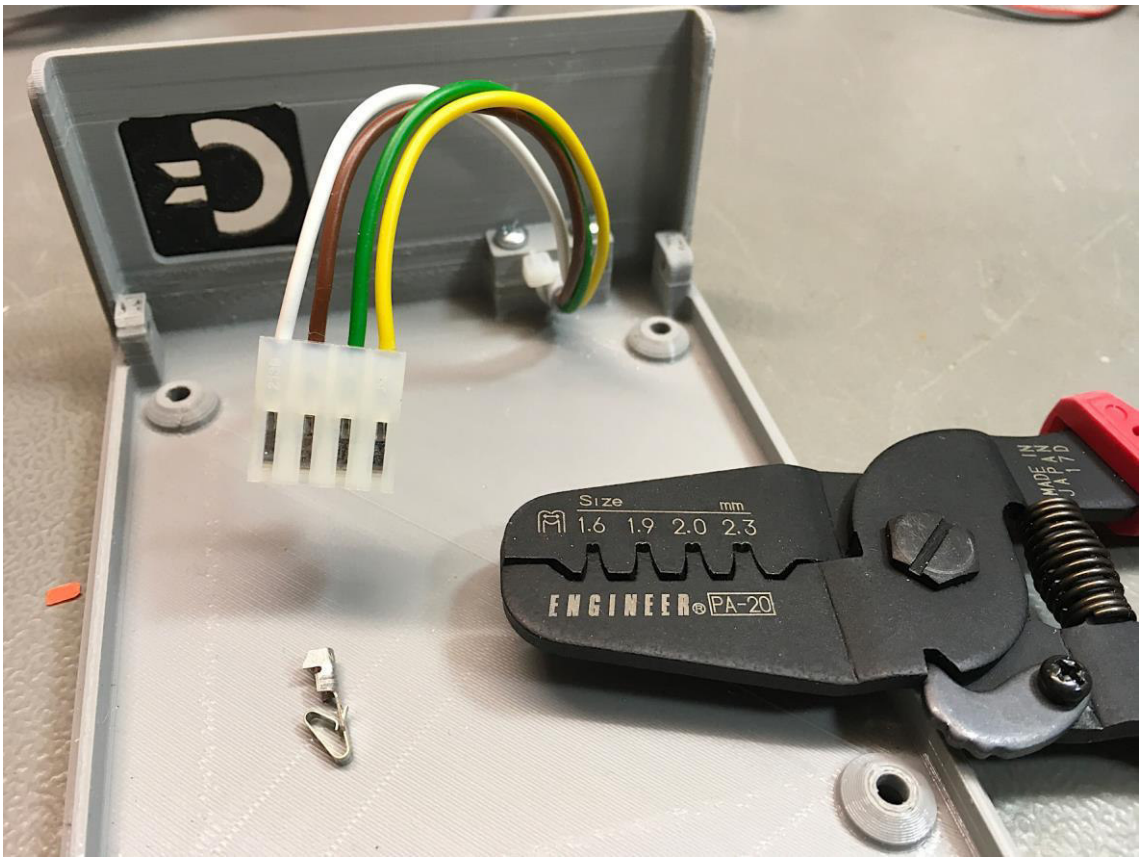


Figure 9: The power cable with crimp housing installed

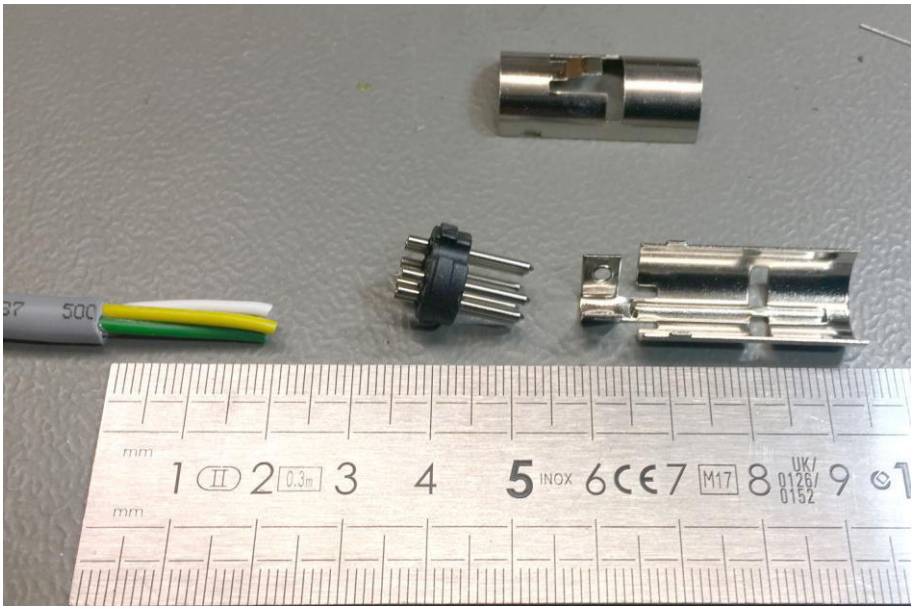


Figure 10: The output (DIN) connector

For soldering the DIN connector, the outer insulation should be stripped off about 12mm. The wire insulation should be stripped off about 2mm. Before soldering, the wire strands should **not** be tinned, otherwise it will not be possible to insert them into the solder cups. A drop of (liquid) flux is helpful for soldering. It should be taken into account, that the body of the connector might melt and the pins get out of alignment. I have heard about the "potato method" for soldering DIN connectors: The connector is pressed into a raw potato. The wires can then be soldered, while the pins stay in alignment.

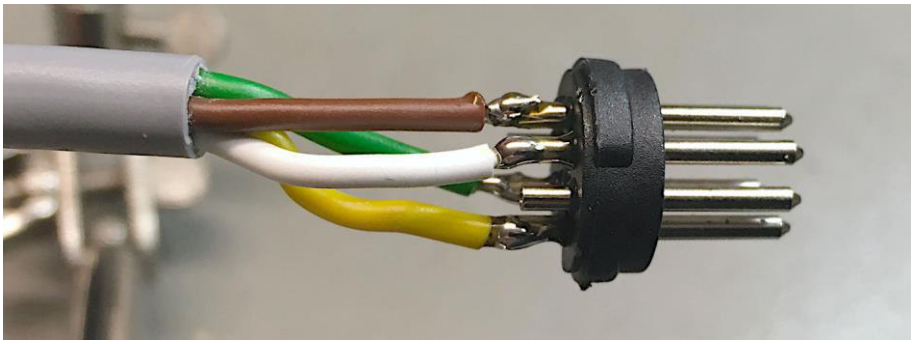


Figure 11: The soldered DIN connector

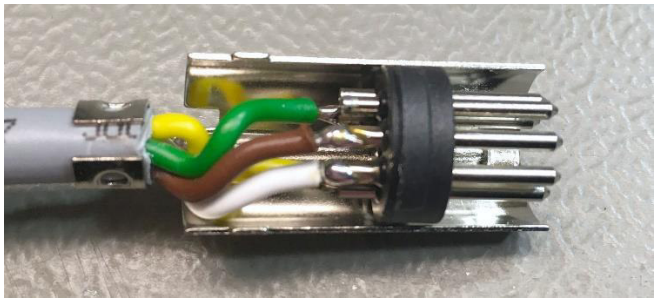


Figure 12: Installing the shielding of the DIN connector

The Logo Cable – W500

The logo can be connected as a power indicator lamp. It connects to a "C64 standard" three-way DuPont connector. The GND wire connects to the middle pin, the plus wire connects to one of the outer pins (either 1 or 3, both is fine).

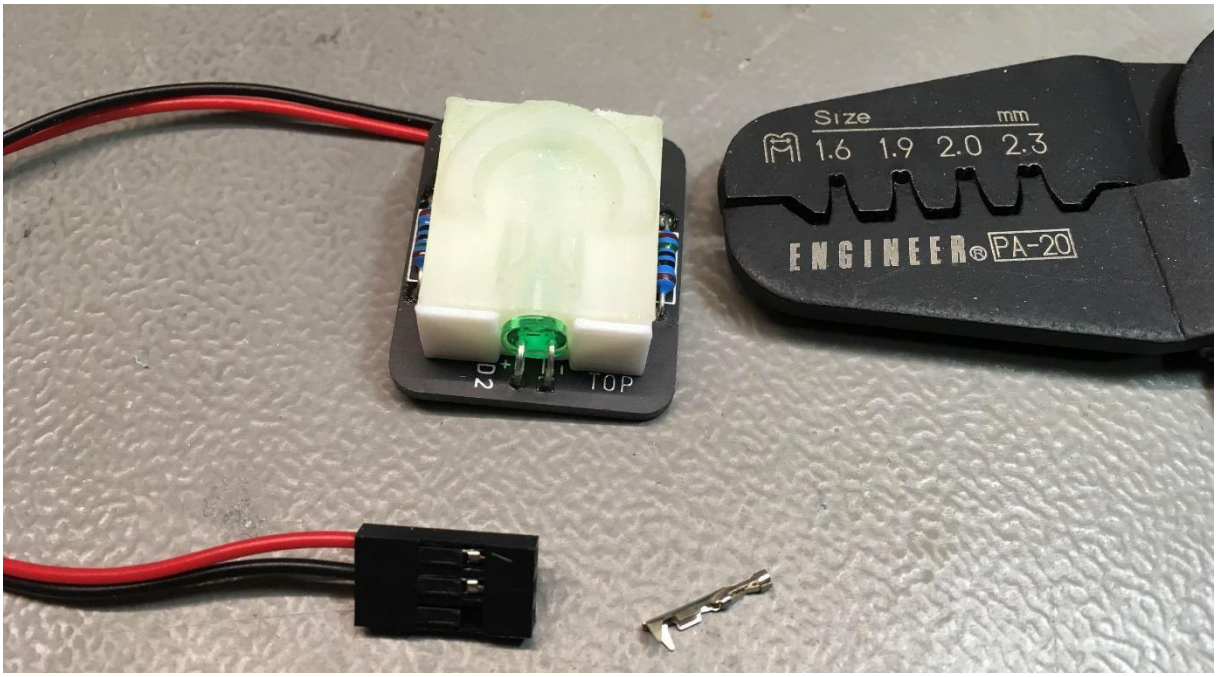


Figure 13: The logo cable - W500

A simple power LED can be connected (in case the PSU is installed in another case). The resistor R1 on the PCB has to be selected accordingly:

- Logo: 0Ω
- Red, green or yellow LED: 330R
- Blue LED: 47Ω - 51Ω

Case material

Required screws

Qty	Material	Purpose
4	M3x10 (DIN7985)	PCB
4	Nut M3 (DIN 985=self-locking)	PCB
2	C2.9x9.5 (DIN 7981)	Strain Relief
2	M3x12, counter sunk (DIN 965)	Appliance connector
2	Nut M3 (DIN 985=self-locking)	Appliance connector
2	M3x12, counter sunk (DIN 965)	Optional: Voltage selector switch
2	Nut M3 (DIN 985=self-locking)	Optional: Voltage selector switch
4	C2.9x6.5, counter sunk (DIN 7982)	Top shell/bottom shell

Figure 14: Required mounting screws

3D Prints

There are two versions of bottom shells and one version of the top shell:

- 230V only bottom shell without a cutout for the voltage selector switch
- 230V/115V with a cutout for the mains voltage selector

The top shell is identical.

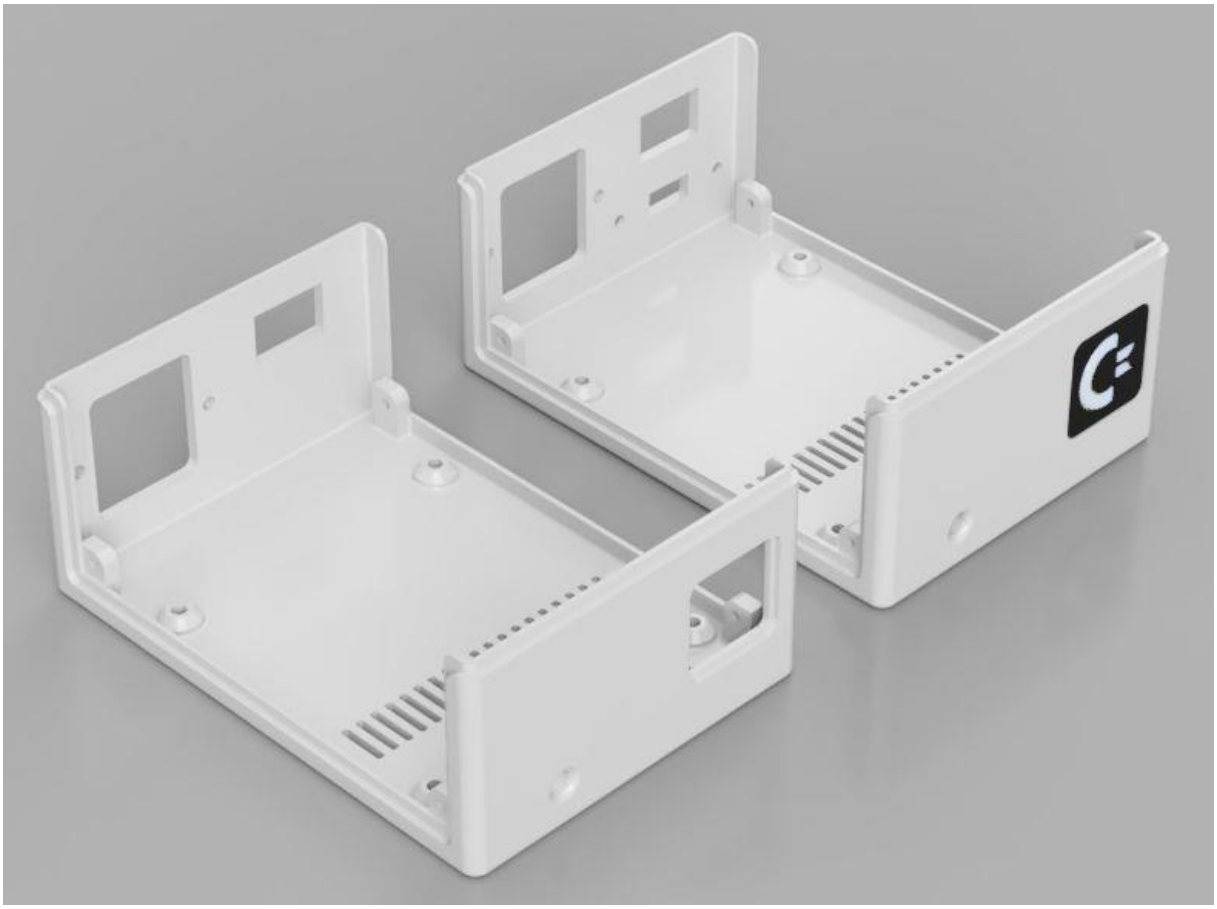


Figure 15: Bottom shells: 230V only (left), 230V/115V (right)

The temperatures can reach 45°C – 50°C inside the case (above the transformer), so it might be a good idea to used something more heat resistant like PETG or ABS for printing the case shells.

Further, there is an illuminated logo. This can be printed with PLA.

You have two options:

- Commodore logo (https://github.com/svenpetersen1965/Illuminated-Commmodore-logo)
- 64 logo (https://github.com/svenpetersen1965/Illuminated-64-logo)

Both logos might be copy right protected.

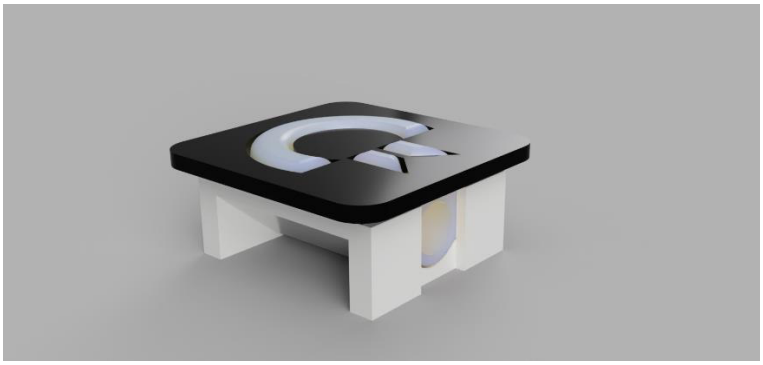


Figure 16: Commodore logo (without PCB)

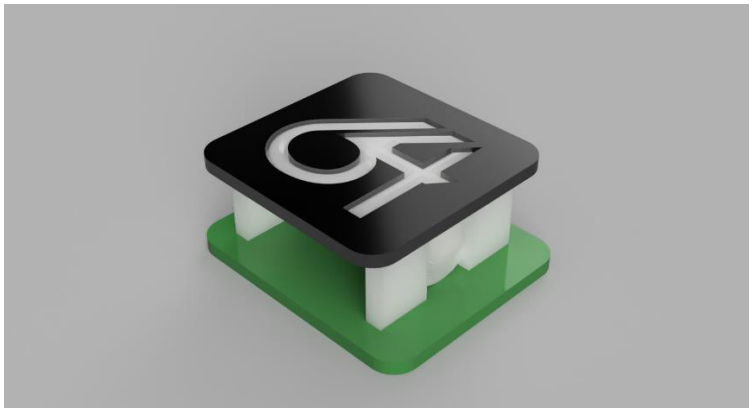


Figure 17: 64-logo (with PCB)

The illuminated body should be printed with clear filament (PLA) 100% infill. The reflector requires some white filament, the face plate should be printed with a dark filament (e.g. black PLA). The PCB is helpful, but also a perf board, which holds the two LEDs and two current limiting resistors is possible. Diffused LEDs are a better choice than clear LEDs, go for the bright ones.

It is not required to have a 3D printed case. Alternatively, a suitable metal case can be used. In this case, you need a strain relief for the output cable.

Assembly inside the 3D printed case

STEP 1

The first step should be gluing in the logo face plate into the bottom shell. A special plastic glue is required, here. The type that dissolves the plastic a bit is recommended, because that is producing an excellent bond. This should dry for some time, so the face plate will stay in place while mounting.

STEP 2

The next step is optional, since the mains voltage selector switch (W300) is only required for the 230V/115V version.

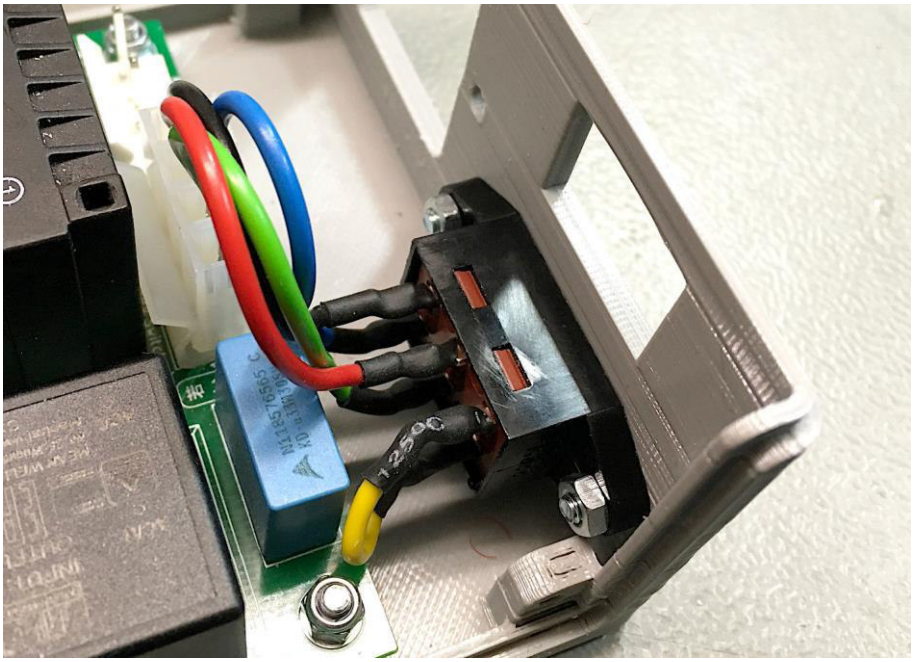


Figure 18: Mains voltage selector installed

This requires two M3x12 counter sunk screws and two nuts. Self-locking nuts are recommended (Figure 18 shows “ordinary” nuts). It is easiest to start without the PBC mounted.

STEP 3

Mount the PCB with four M3x10 screws and 4 M3 self-locking nuts. The side with J1 and J2 is oriented towards the cutout for the power switch and the appliance connector. The already installed power output cable (W400) and the optional W300 voltage selector can be connected to the PCB.

STEP 4

The mains cable (W200) should be connected to the PCB. Before screwing the appliance connector/mains cable (W100) to the case, the green/yellow PE cable should be connected to the appliance connector (Figure 19). The latter is then mounted with two M3x12 countersunk screws and M3 nuts.

The cutout dimensions are:

27.7mm x 31.7, screw distance: 36mm.

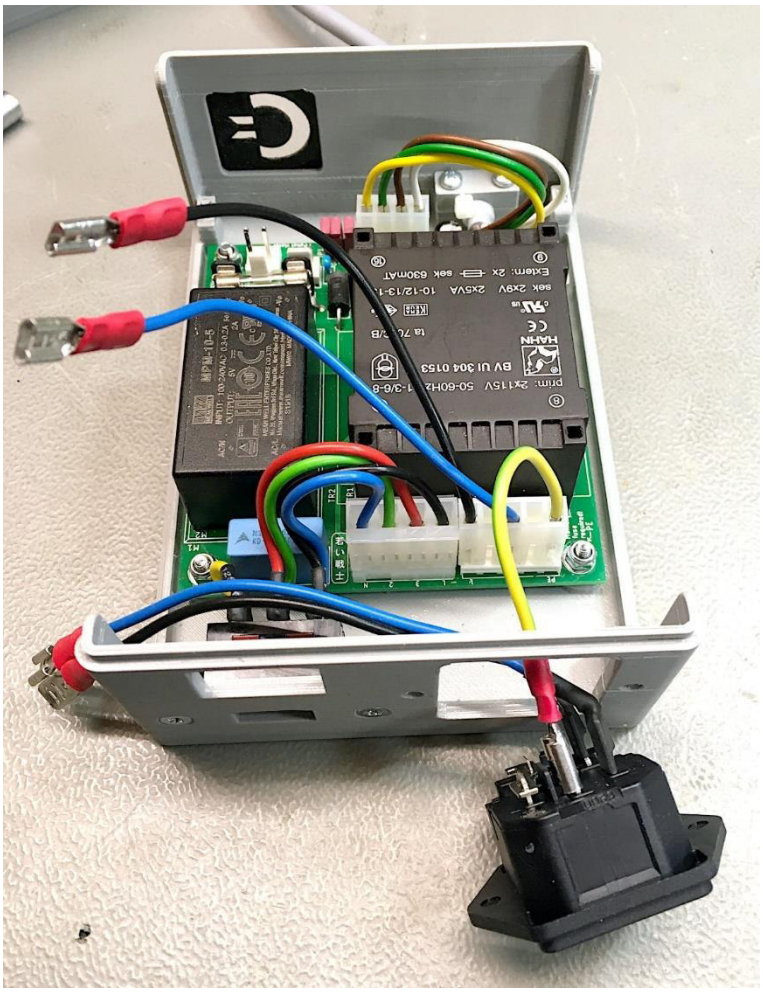


Figure 19: Installing the mains cable W100

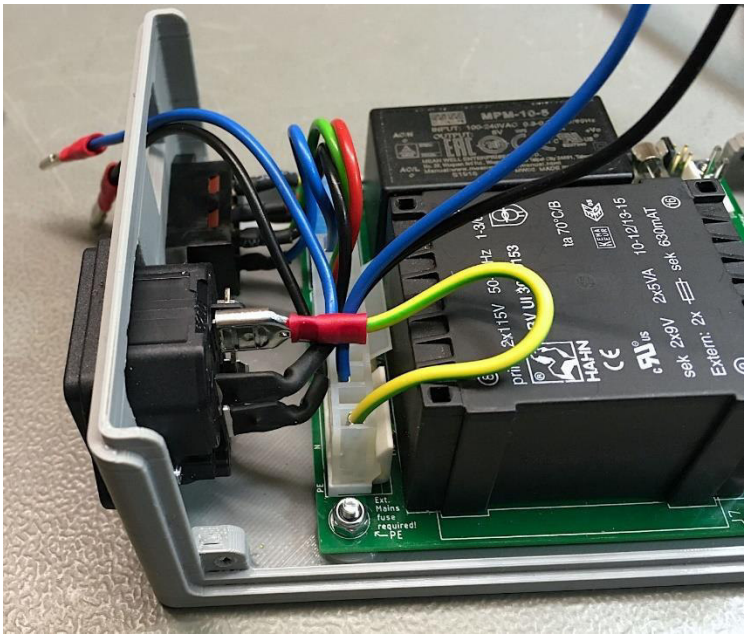


Figure 20: Mains cable W100 installed

STEP 5

This is installing the power switch. It can either be an illuminated version or a non-illuminated version. The tests at 115V have shown, that an illuminated (230V) switch is pretty dim then. Here, a normal power switch, that fits the cutout (19.8mm x 13mm) might be the better choice.

The illuminated switch has to be wired, that the lamp is connected to the output side of the switch.

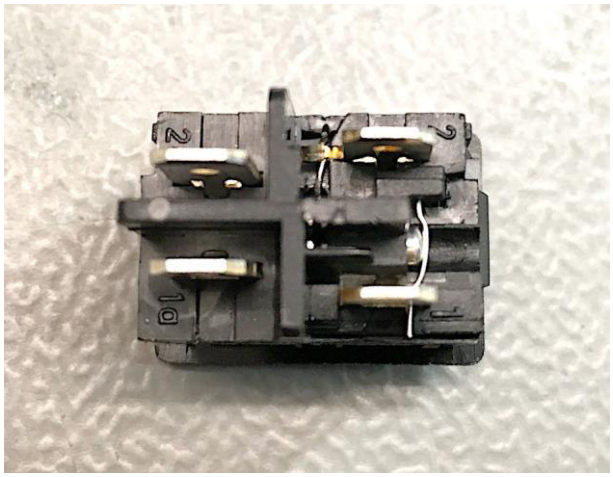


Figure 21: Illuminated mains switch

Figure 21 shows the mains switch. Here, the input side is at the left, the output side with the lamp connected is at the right.

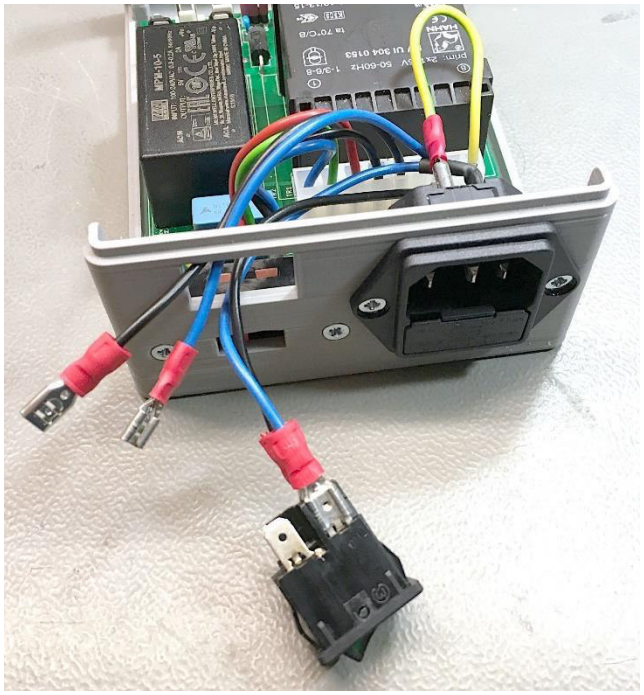


Figure 22: Installing the mains switch

The mains input from W100 connects to the input side of the switch (Figure 22).

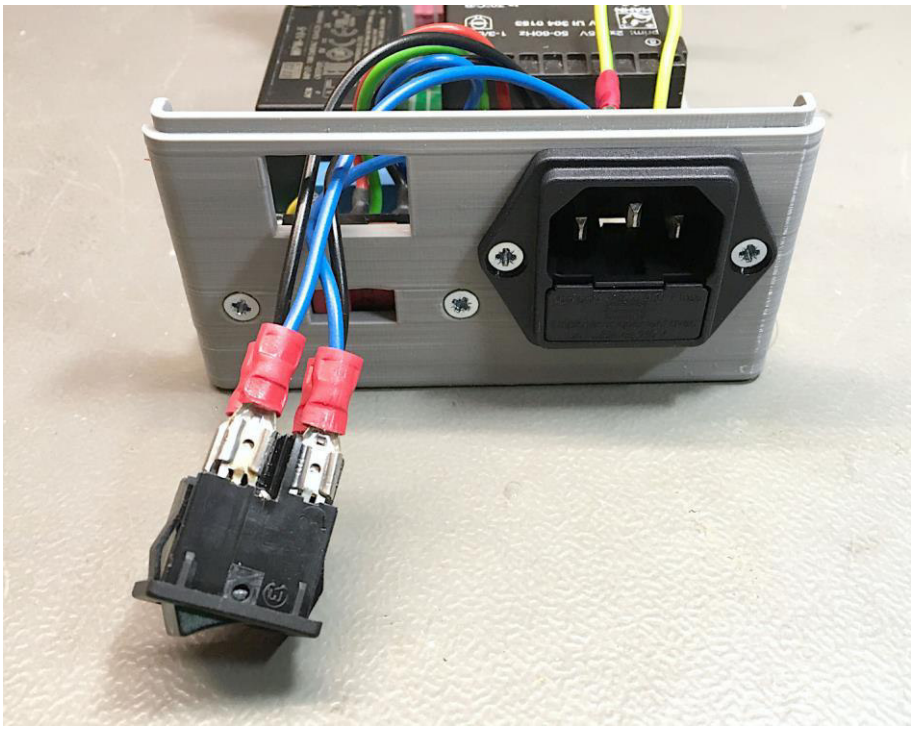


Figure 23: Mains switch wired

The mains cables from the PCB (W200) connect to the output side of the power switch. Blue (N) should be adjacent to blue and black (L) to black (Figure 23). Finally, the switch can be pressed into the cutout. It should snap in place and stay firmly (Figure 24).

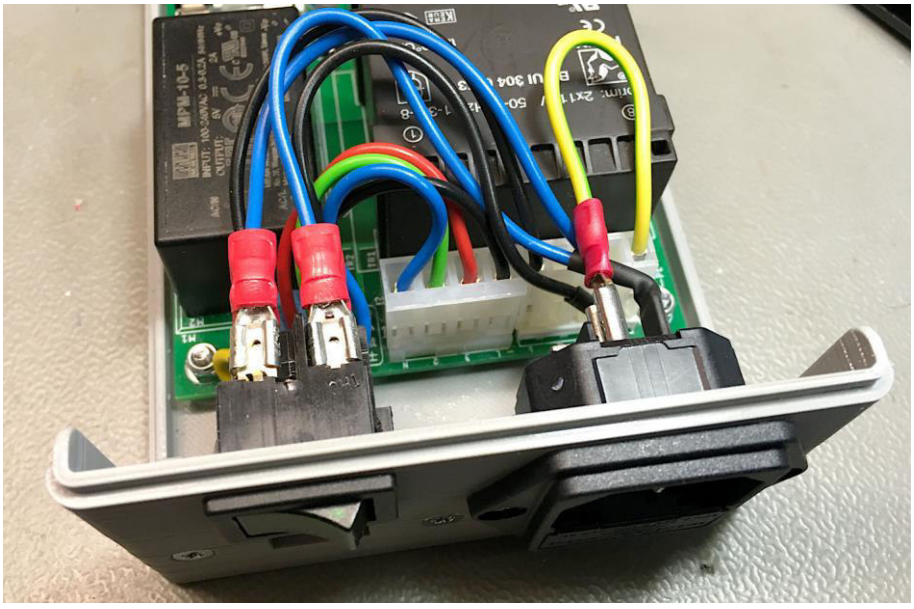


Figure 24: Mains switch installed

STEP 6

Finally, the logo has to be glued in place. Again, the same plastic glue like in STEP 1 is recommended. The logo should be clamped to the case for a while to let the glue dry. The logo cable W500 is then connected to the LED connector J6 (Figure 25).

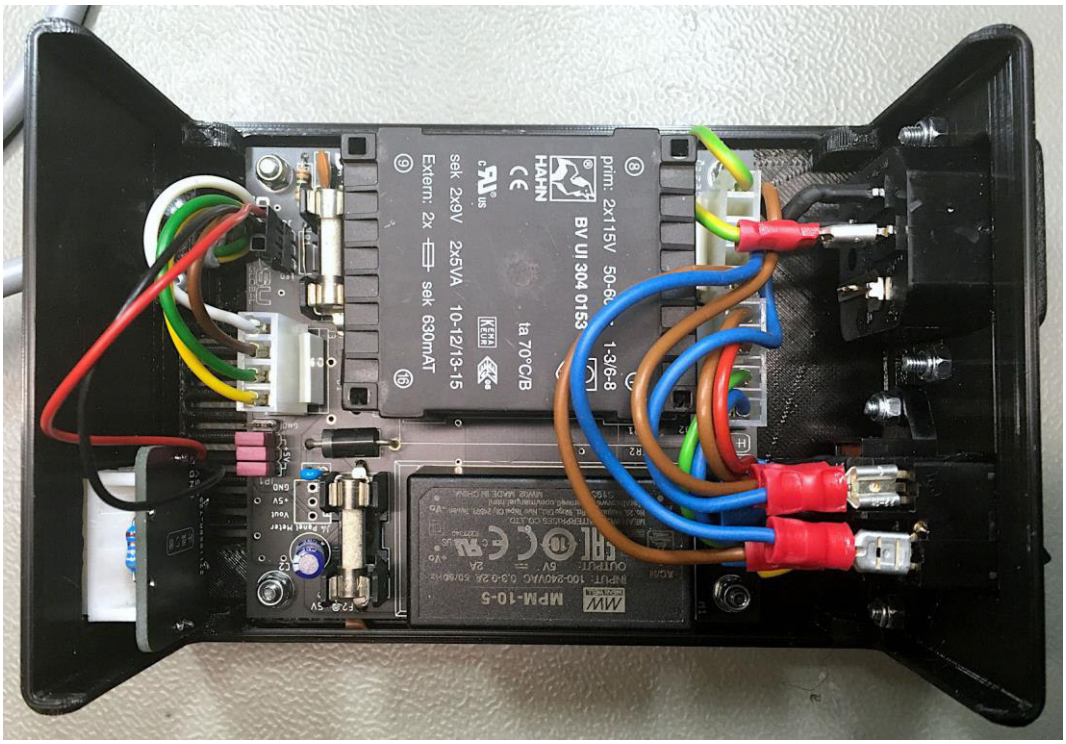


Figure 25: PCB Rev. 1 completely wired

Now, the top shell is slid over the bottom shell. The desired orientation is marked inside. “FRONT” should point to the output cable side. It is screwed in place with the four C2.9x6.5 countersunk screws.

Figure 26: Completed Power Supply Global

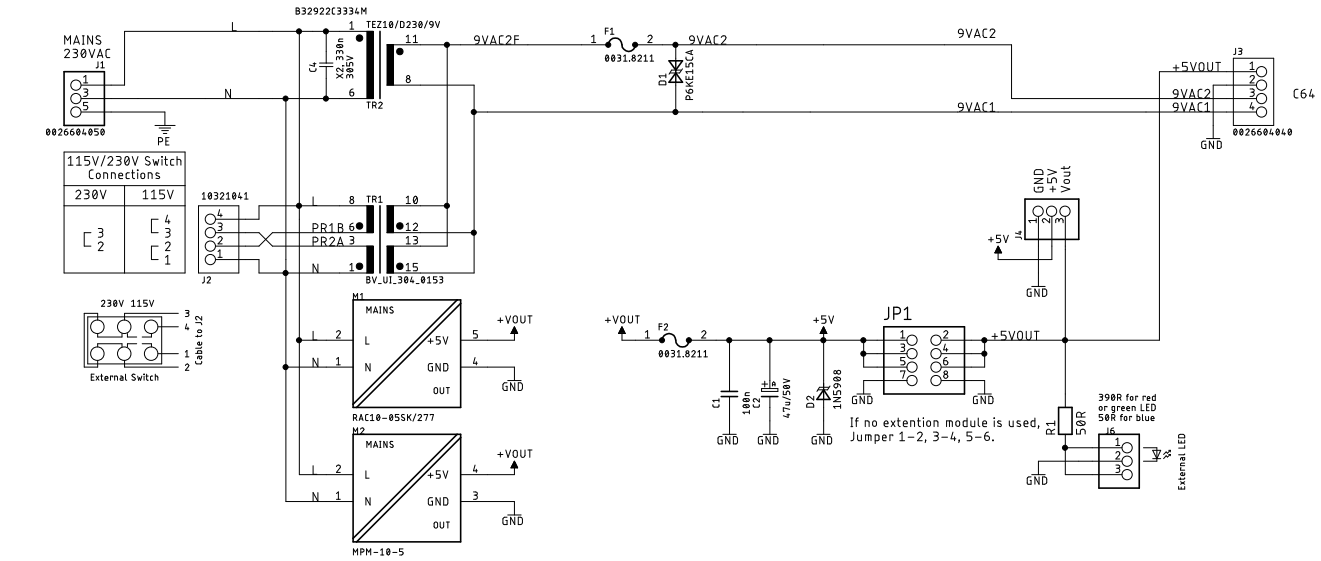
Testing

After finishing the wiring, it is required to test the complete device. Swapping the voltages by confusing the pins or the wiring will usually damage the connected devices. The +5V should measure between +4.9V and +5.2V. The 9VAC are not regulated and is quite a bit higher without load. 12VAC is still an acceptable reading. For the pinning, refer to Table 2: Power jack of the C64. Remark: When looking at the pin side of the connector, the pinning is mirrored.

Revision History

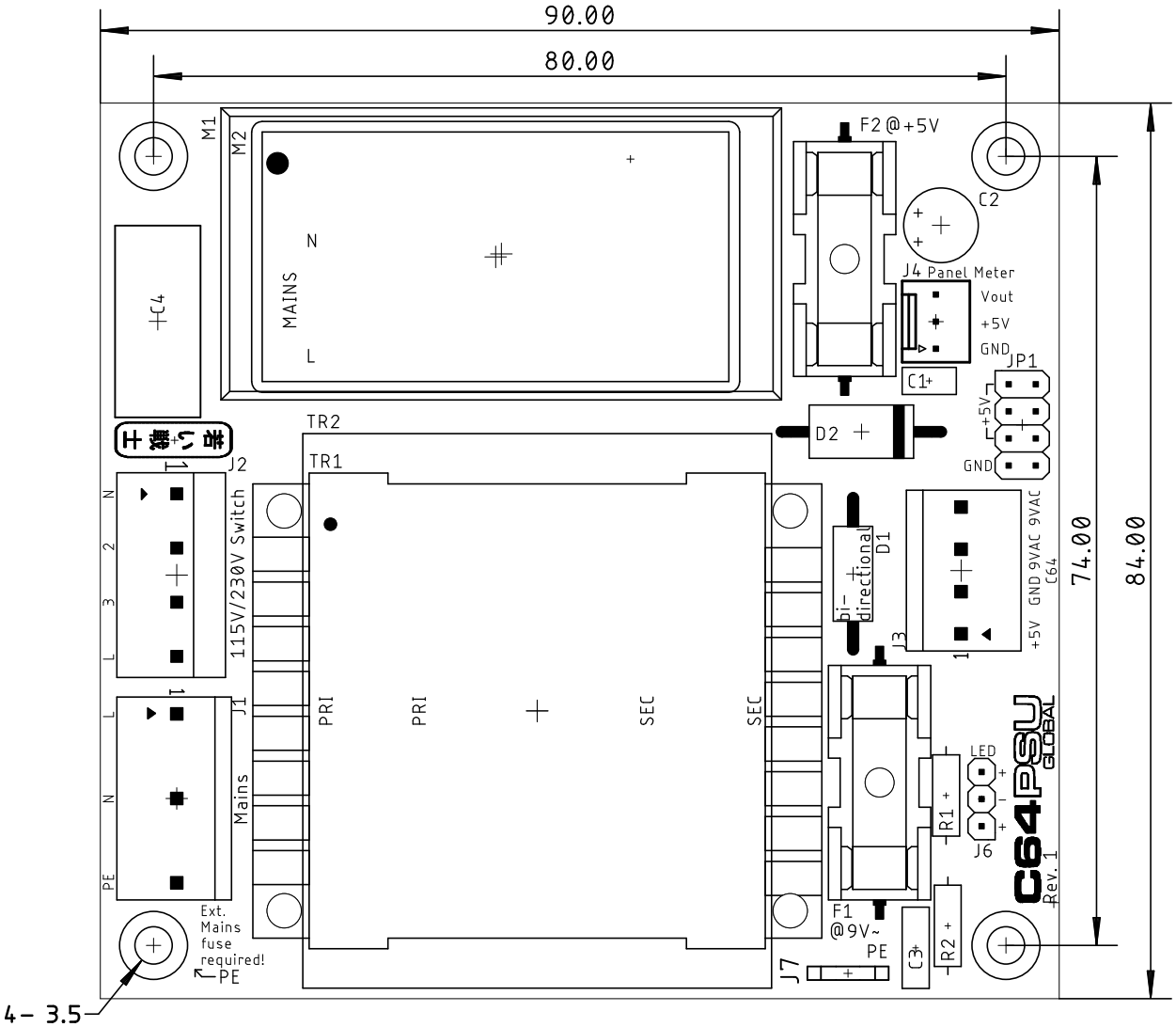
Rev. 0 → Rev. 1

Since the tests have shown, that a panel meter is very inaccurate measuring the current, the current measurement path has been dropped. Only panel volt-meters can be connected. For the sake of a minimum voltage drop, the current-carrying copper-traces with a 5V level are as wide as possible. The pin-header, that can connect to an optional voltage supervisor ("saver") has been changed from 6 pins to 8 pins (three pairs of 5V pins instead of two). The reason is also minimizing the voltage drop over this connector.

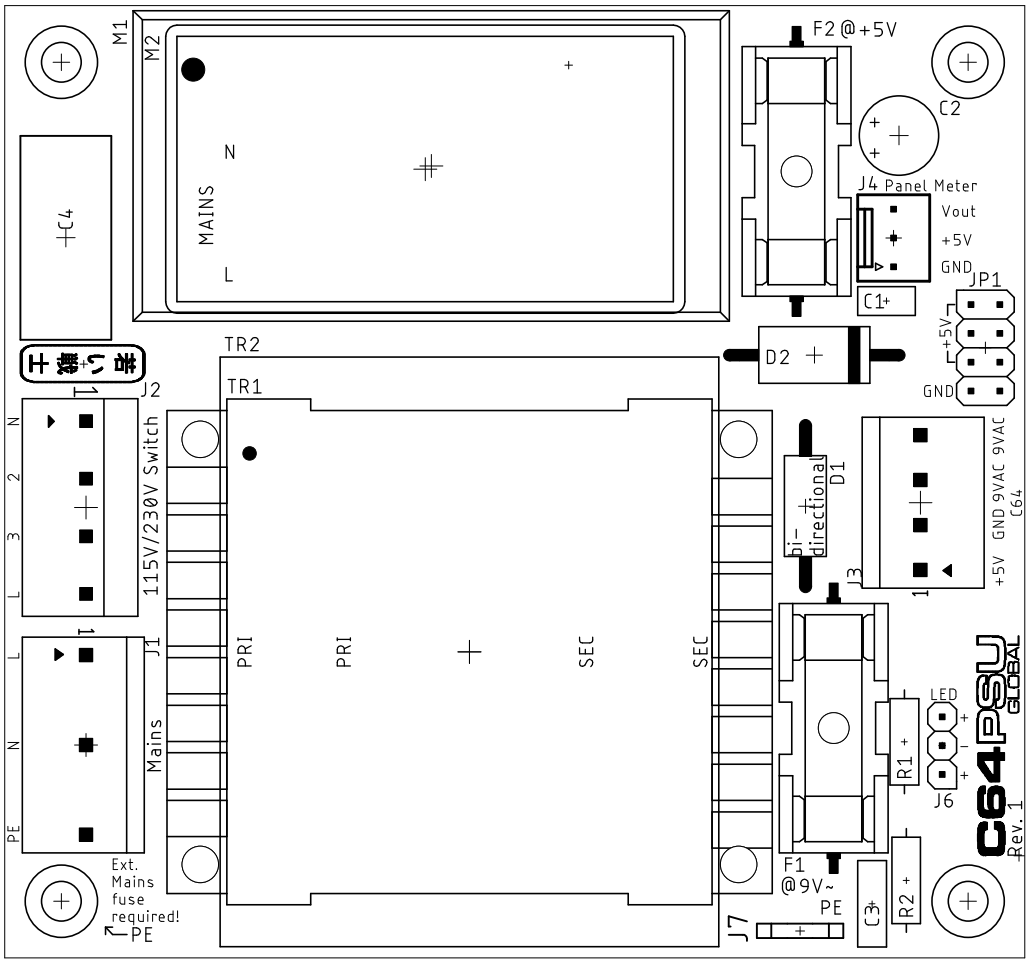


Title:	C64 PSU (115V/230V)	Doc.-No.:	133-1-01-01
		Draft.:	Sven Petersen
Date:	18.02.2020 17:45	Rev.: 1	Page 1/1
File:	C64_PSU_global		
			A3

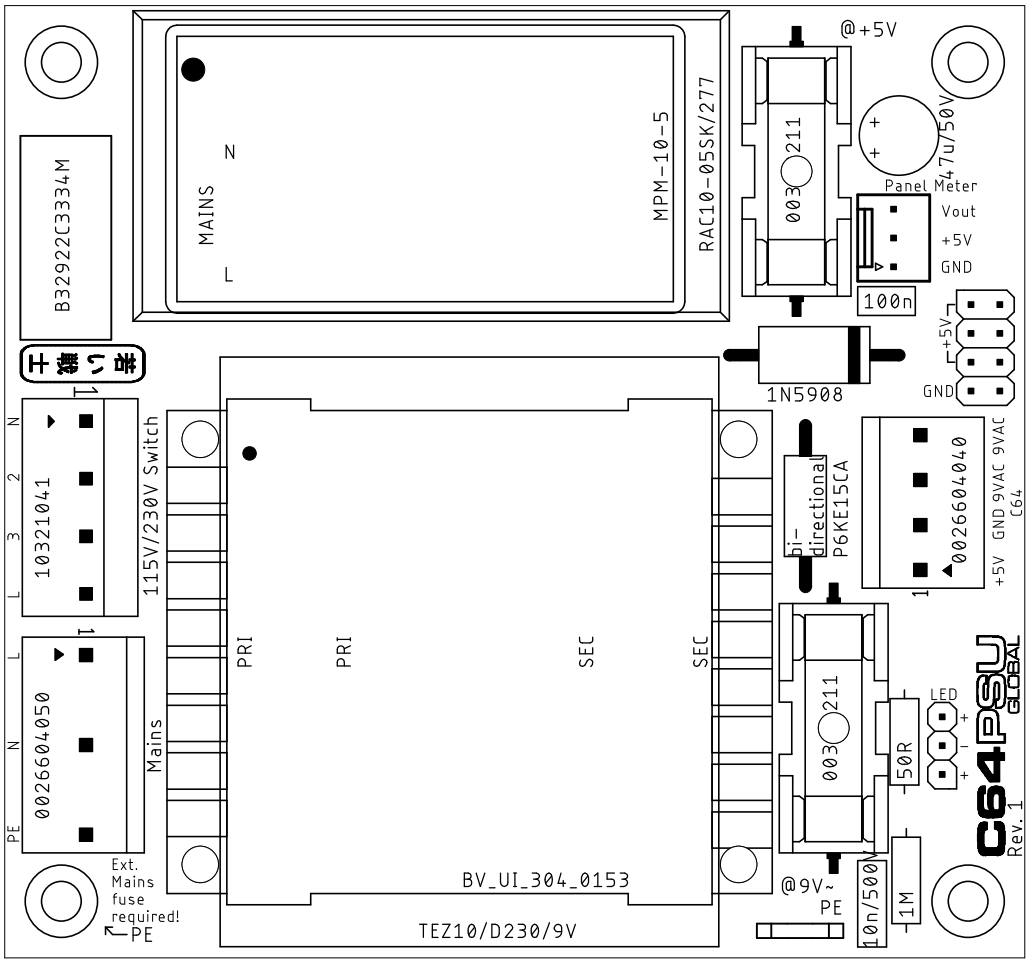
Sven Petersen 2020	Doc.-No.: 133-1-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_PSU_global		
18.02.2020 18:12	Rev.: 1	
placement component side measures		



Sven Petersen 2020	Doc.-No.: 133-1-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_PSU_global		
18.02.2020 18:12	Rev.: 1	
placement component side		



Sven Petersen 2020	Doc.-No.: 133-1-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_PSU_global		
18.02.2020 18:12	Rev.: 1	
placement component side		



Sven Petersen 2020	Doc.-No.: 133-1-01-01	
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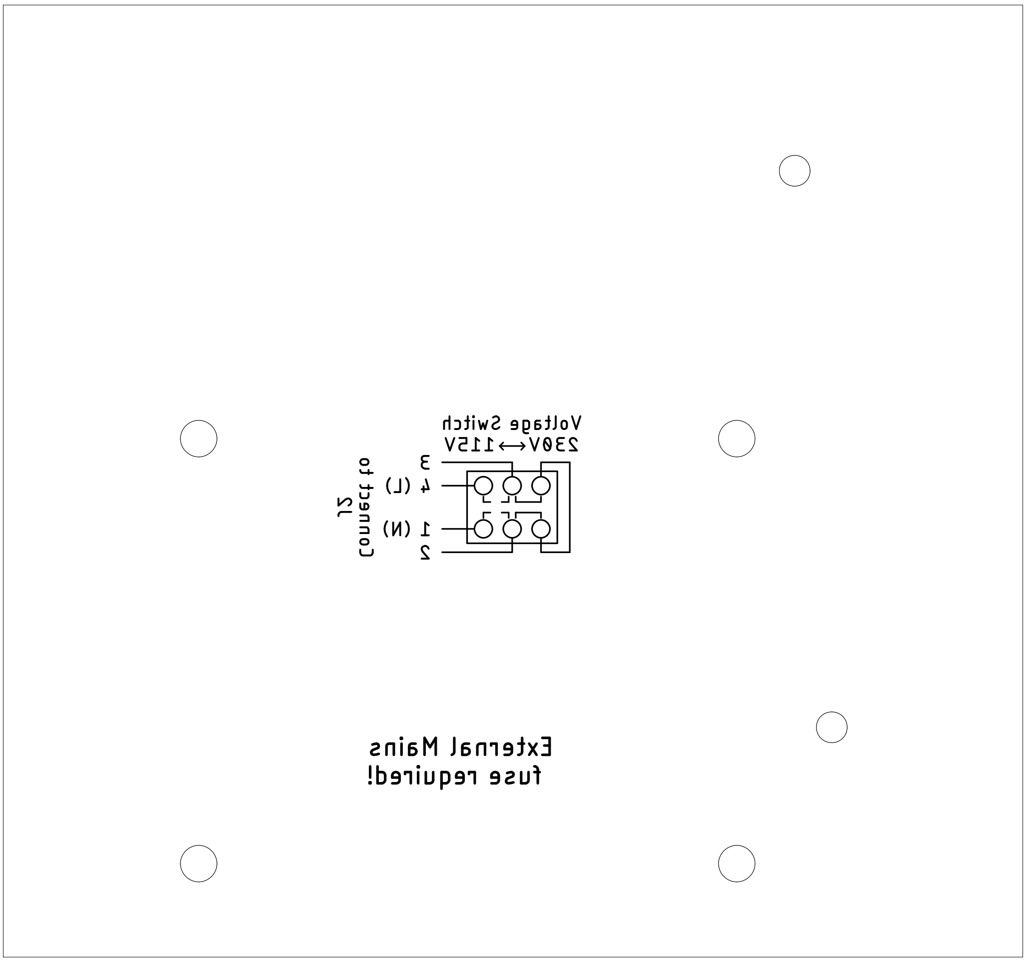
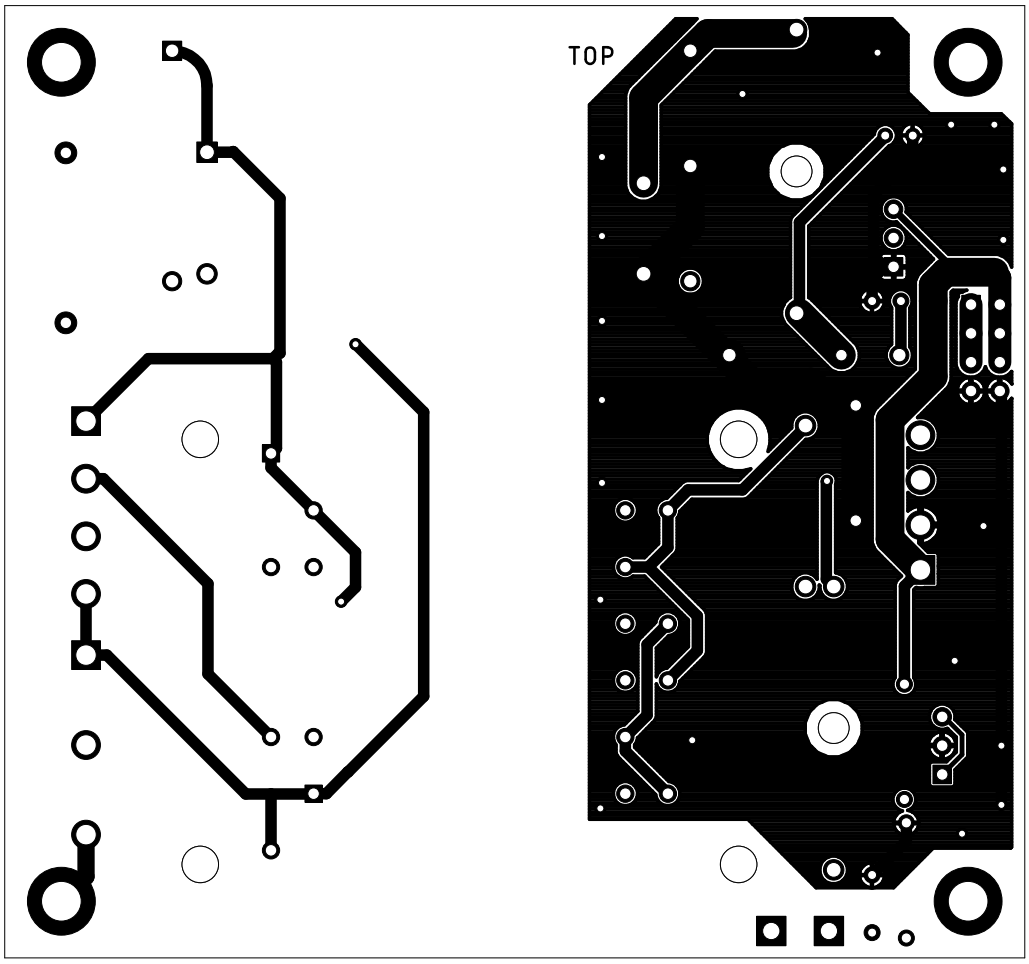
C64_PSU_global		
18.02.2020 18:12		Rev.: 1
placement solder side		



Sven Petersen 2020	Doc.-No.: 133-1-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_PSU_global		
18.02.2020 18:12		Rev.: 1
top		



Sven Petersen 2020	Doc.-No.: 133-1-01-01	
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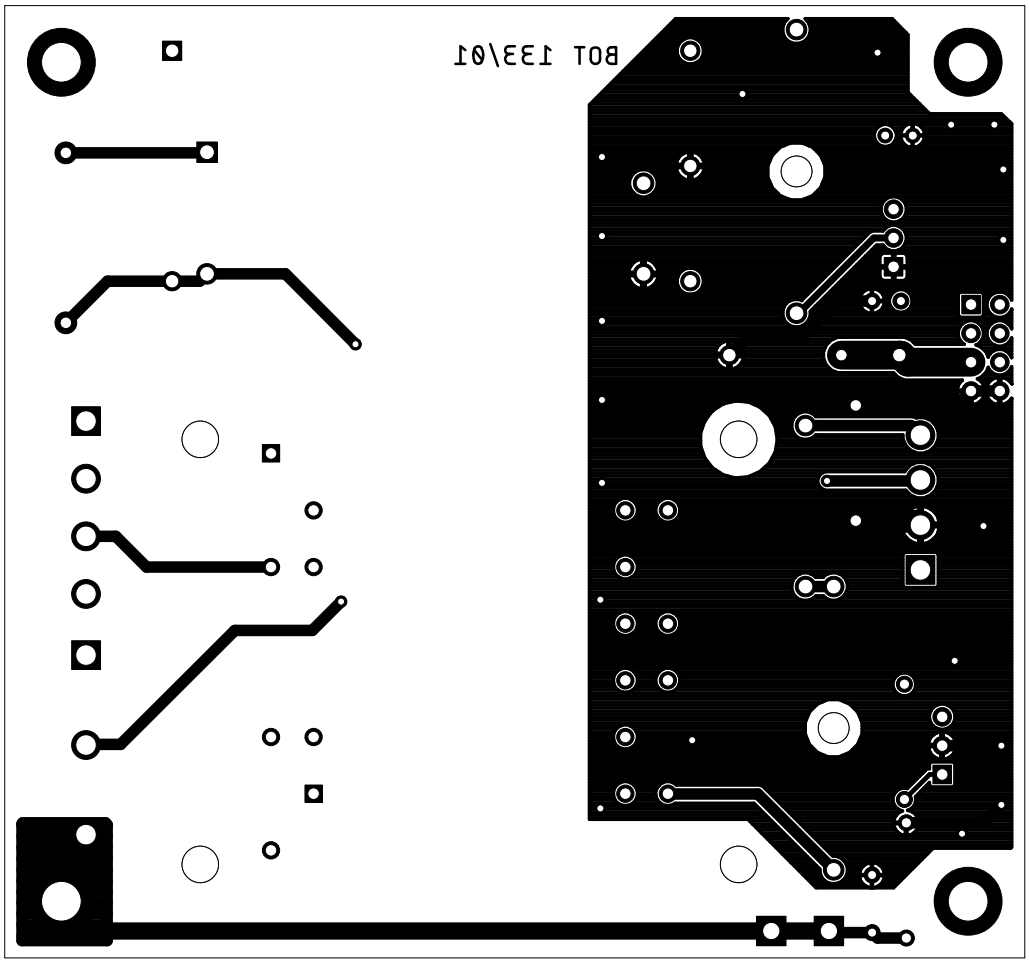
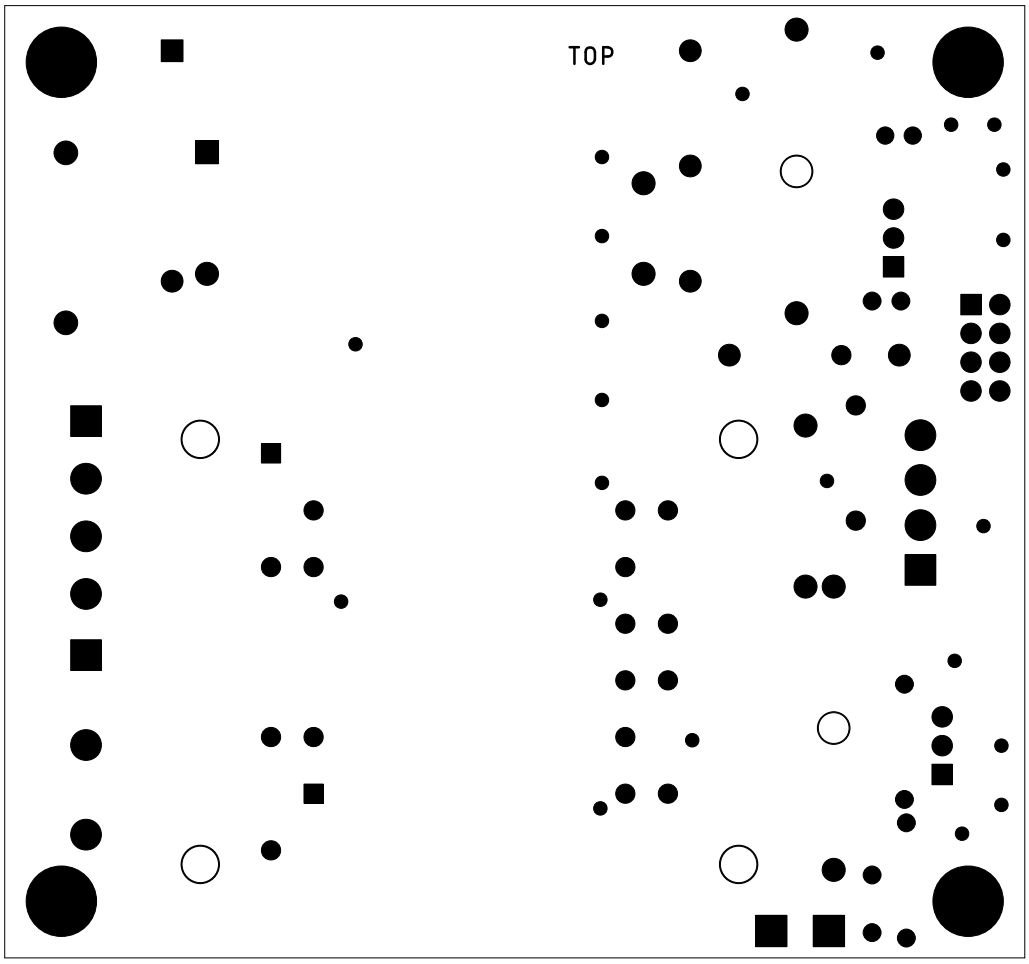
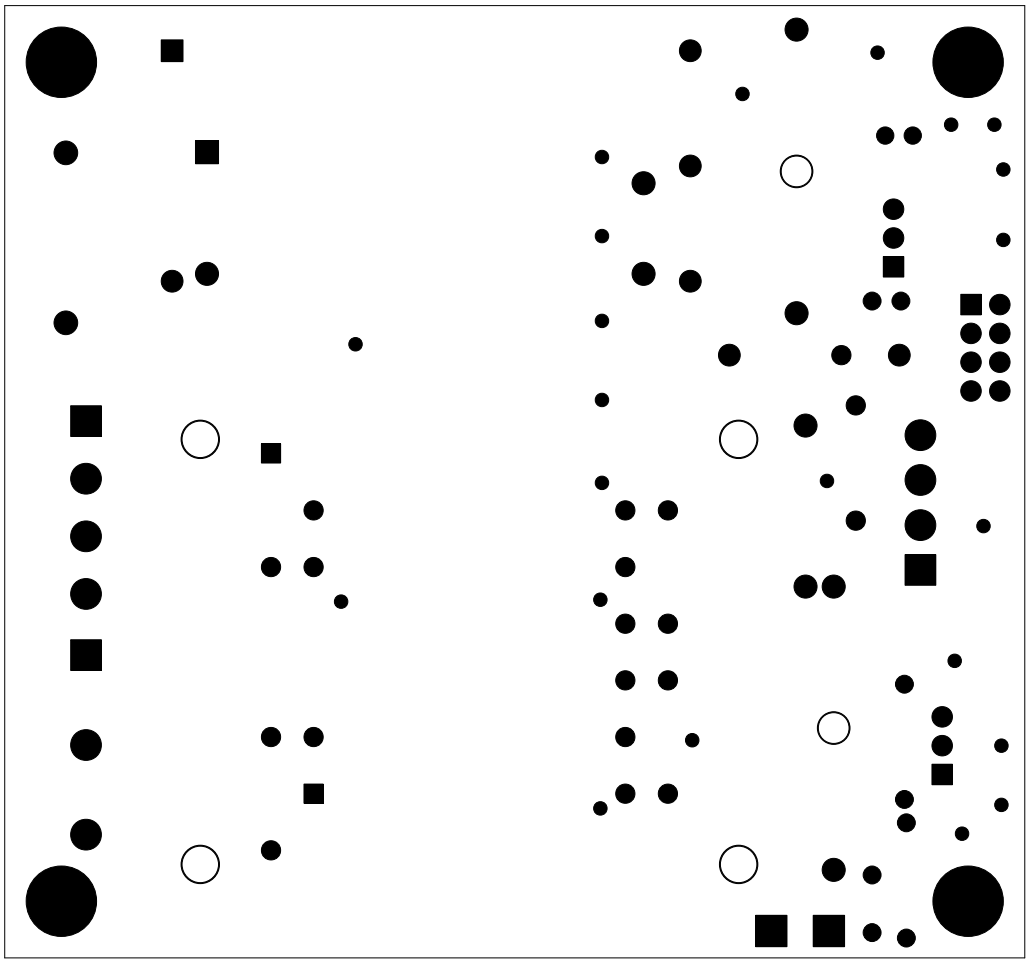
C64_PSU_global		
18.02.2020 18:12		Rev.: 1
bottom		



Sven Petersen 2020	Doc.-No.: 133-1-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_PSU_global		
18.02.2020 18:12		Rev.: 1
stopmask component side		



Sven Petersen 2020	Doc.-No.: 133-1-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_PSU_global		
18.02.2020 18:12		Rev.: 1
stopmask solder side		



C64 PSU Global Rev. 1

Functional Description

J1 is the mains connector of the board. Up to 240V can be connected. Two types of transformers fit alternatively. TR2 is for 230V only, TR1 can be switched between 230V and 115V. In this case J2 has to be populated. The wiring and connections are shown in the schematics.

M1 and M2 are AC/DC modules, which provide +5V. Both modules can be populated alternatively. The criteria for choosing one of these is availability and price. The function is identical in this case.

F1 is the fuse for the 9VAC. D1 serves as an over-voltage protection.

F2 is the fuse for +5V. C1 and C2 are for smoothing the voltage, D2 is a **minimal** over-voltage protection. It is equivalent to the TVS diodes, which are sometimes retrofitted in the C64.

JP1 is for connecting an external (and hopefully more precise) over-voltage protection (aka "Saver"). This saver is not yet developed. In case no saver is installed, JP1 should be bridged.

J4 is for connecting a panel volt-meter.

J6 is for connecting a power LED. The value of R1 is calculated for installing a blue LED. For a red or green LED, 330R or 390R are recommended. The illuminated logo already has limiting resistors on board. In case this logo is used as a power indicator, R1 needs to be 0Ω or can be bridged with a piece of wire.

C64 PSU Global Rev. 1

Testing v1.0

Devices under Test

The tests were conducted with two versions of the C64 PSU Global Rev. 0:

A. Version 115V/230V with TR1 (Hahn BV UI 304 0153) and AC/DC M2 (Mean Well MPM-10-5)
B. Version 230V with TR2 (BREVE TUFVASSONS TEZ10/D230/9V) and AC/DC M1 (RECOM RAC10-05SK/277)

The mains voltage was fix (230VAC) for most measurements. The voltage measurements were conducted with Rev. 0 and Rev. 1 of the PCB.

Tests

Testing Under Real Life Conditions

The setup for the function test was both versions, connected to a C64 with different ASSY No., an Ultimate II+ and a joystick switch was attached to the respective mainboard (Figure 1).

Figure 1: Testing the PSUs under real life conditions

C64 ASSY No.	Version A	Version B
250407	C64 started, software loaded and worked properly	C64 started, software loaded and worked properly
250425	C64 started, software loaded and worked properly	C64 started, software loaded and worked properly
250466	C64 started, software loaded and worked properly	C64 started, software loaded and worked properly
250469	C64 started, software loaded and worked properly	C64 started, software loaded and worked properly

Output Voltages with and without Load (Rev. 0)

The load is a 4.7Ω resistor for the 5VDC and a 10Ω resistor for the 9VAC.

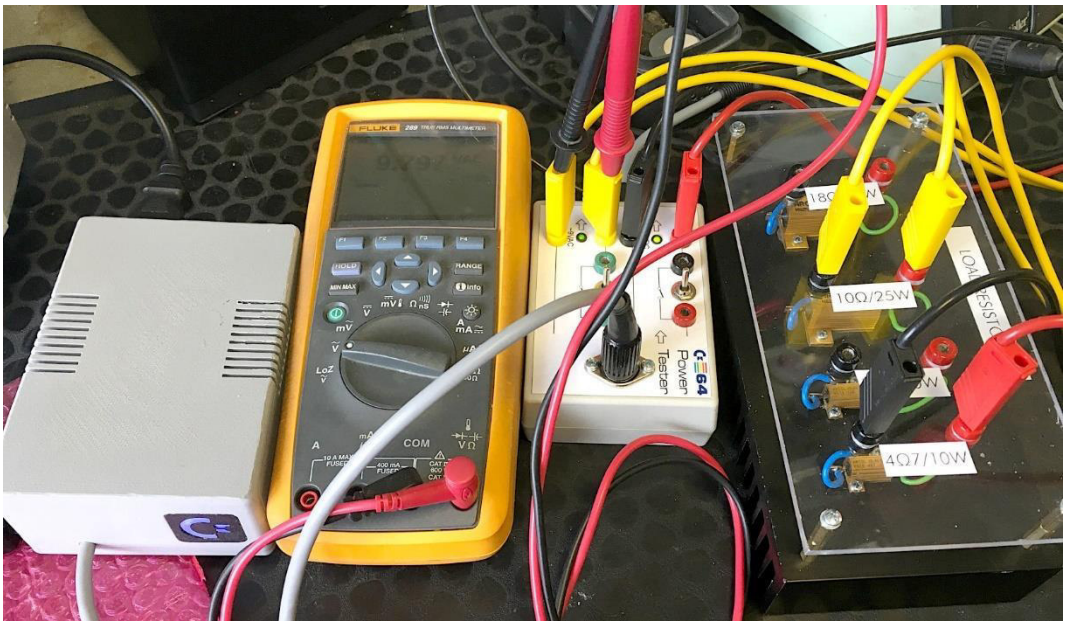


Figure 2: Test Setup

Device under Test (Rev. 0)	No Load		Load	
	5VDC	9VAC	5VDC	9VAC
Version A	4.99V	12.15V	4.76V	10.04V
Version B	5.00V	11.61V	4.73V	9.73V

The 9VAC output voltage is not critical, all voltages that are generated from it in the C64 are regulated. An output voltage of about 12V at no load is a normal value, which can be observed with transformers, which will output the nominal voltage at nominal load.

The value of the 5VDC is more critical here. The voltage drop of 250mV @ 1A is resulting from the voltage drop over the PCB tracks, the fuse, the connectors and the cable. It does not seem to be critical, since all ASSY Numbers, which are tried out, worked flawless over a longer time. Anyways, this voltage drop should be investigated further and minimized.

Output Voltages with and without Load (Rev. 1)

In Rev. 1, the connection for a current panel meter was dropped, since the accuracy of those panel meters was considered to be not sufficient. This should have an effect on the voltage drop on the

PCB. Thus, the measurements conducted with Rev. 0 were repeated with Rev. 1 to observe the effects of the modification.

Voltage	No load	Load	Current
+5VDC	4.995V	4.803V	0.989A
9VAC	12.500VAC	10.234VAC	1.008A

The **voltage-drop (192mV)** is now tracked within the system.

The voltage-drop measured directly across the 5V fuse F2 was 68.5mV (of which 10mV are caused by the fuse holder). The complete voltage-drop measured over pin 1 and pin 2 of the output jack J3 was 100mV. The output cable (88cm) contributed another 92mV. So, the cable contributes about half of the voltage drop. An AWG21/0.5mm² cable provides a resistance of 43.4Ω per meter. Since both, the +5V and the GND wire have to be taken into account, an 88cm cable has a resistance 76.4Ω. The calculated voltage drop is about 76mV. The connector of the test box might be responsible for the difference.

Conclusion: The output cable should be as short as possible. A different fuse type might have a less voltage-drop (a not approved 10A fuse produces only 5mV of drop).

The board design is good. 2oz of copper instead of 1oz are not worth the extra price, since the copper traces provide the least part of the voltage drop.

The measurements were carried out with an eevBlog 121GW multimeter.

Ripple measurement

The +5V output voltage was inspected with a scope (Rigol MSO4024). A load of 4.7Ω was applied to this output.

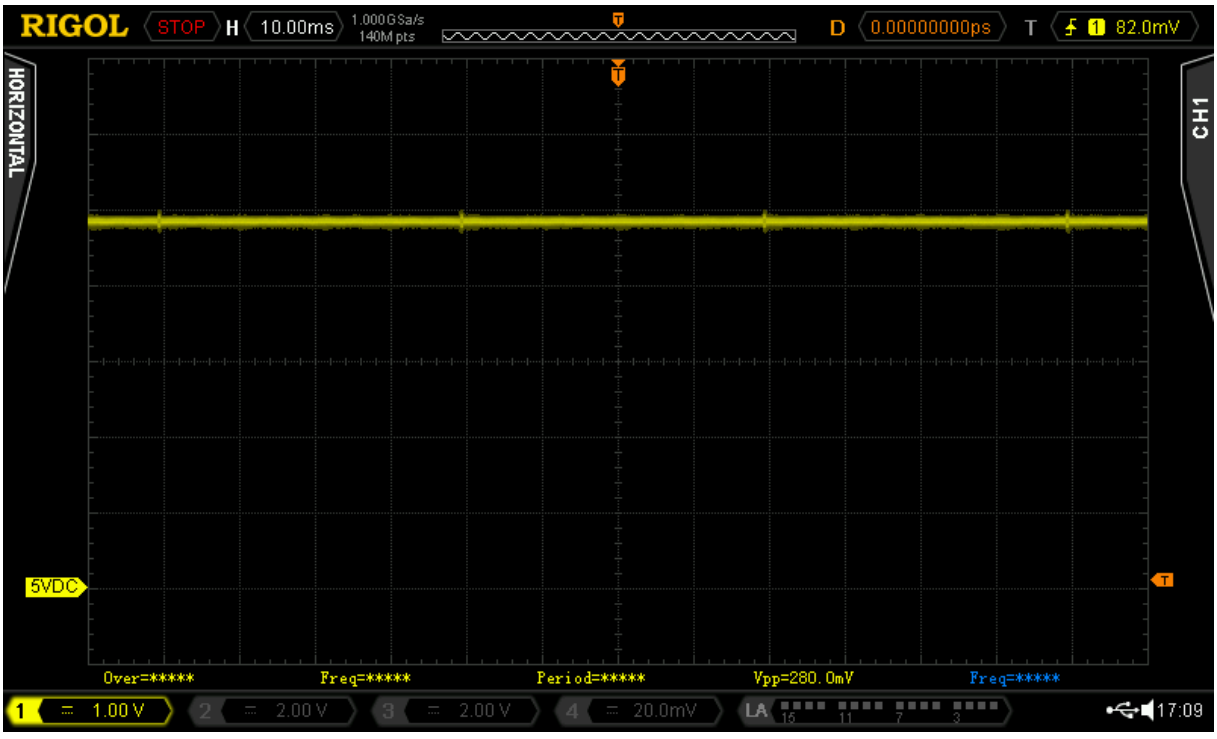


Figure 3: 5VDC (DC coupling, 1V/div and 10ms/div)

A voltage spike was found every 40ms. This should now be investigated further. #

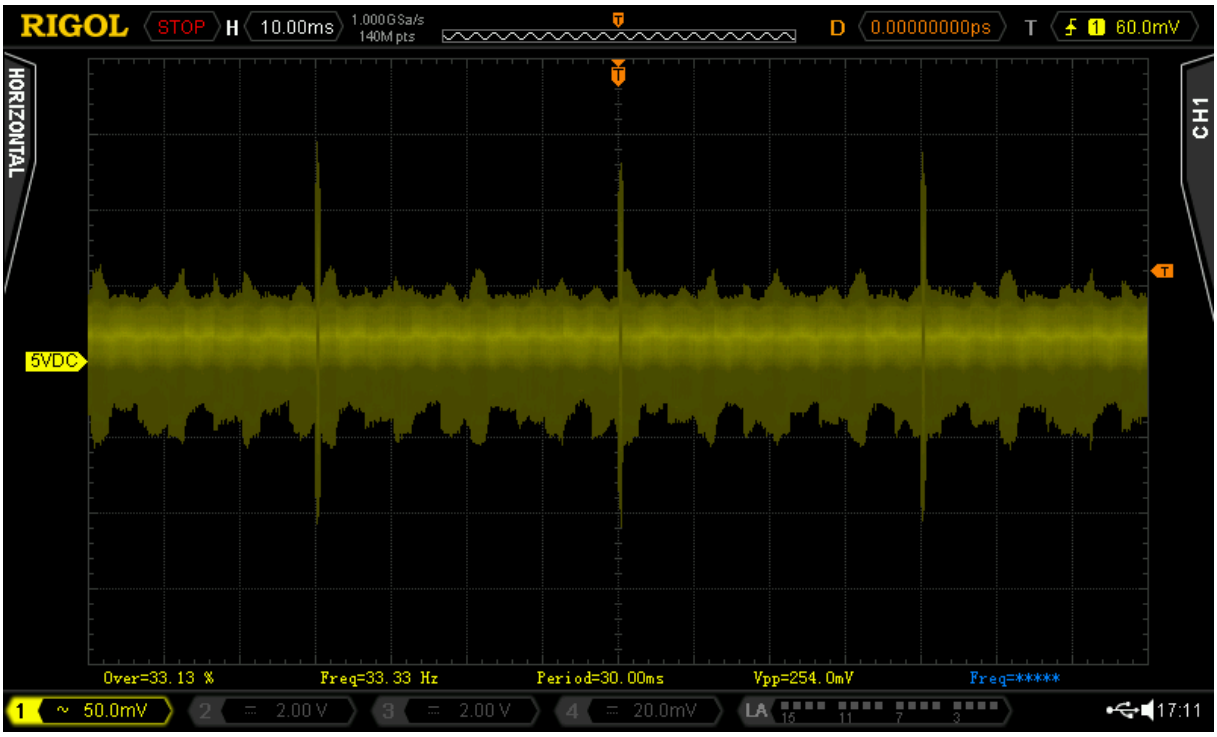


Figure 4: AC coupling, 50mV/div and 10ms/div

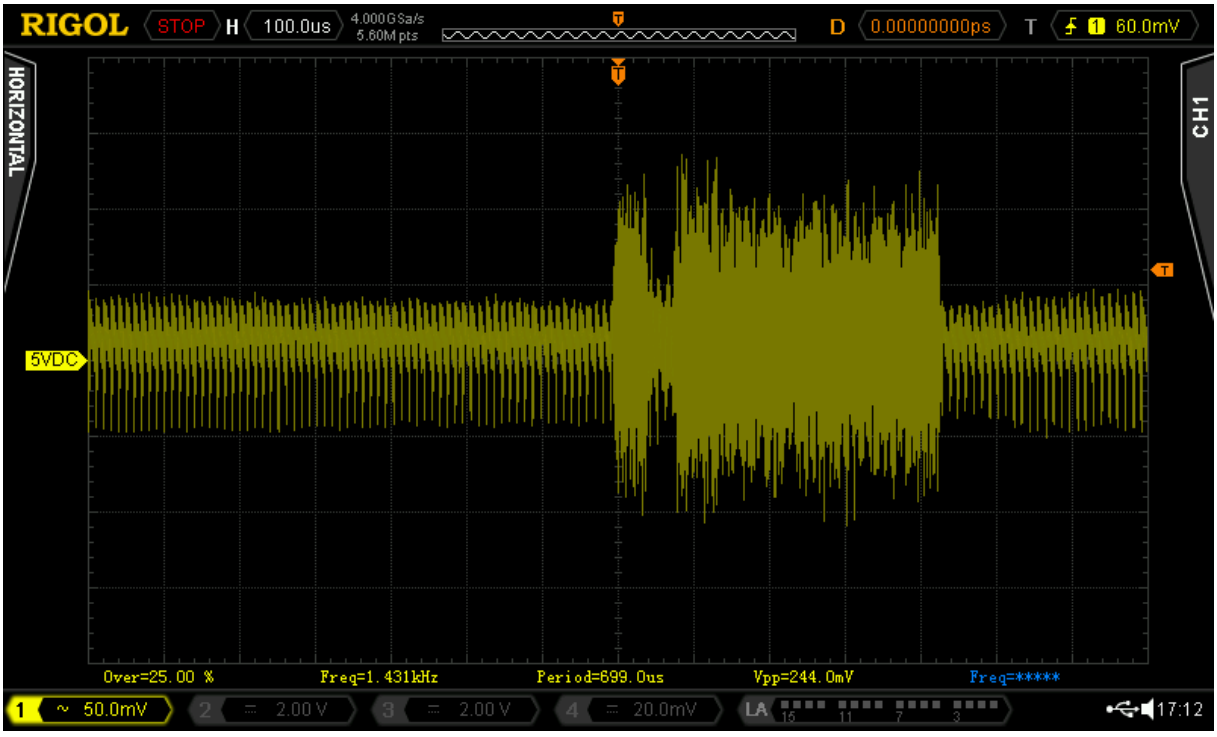


Figure 5: AC coupling, 50mV/div, 100µs/div

The spike or burst that occurs every 40ms has 244mV$_{PP}$ (peak to peak voltage) for about 430µs, while the remaining time, the ripple says within 100mV$_{PP}$. This is not unusual. The input filter of the C64 might flatten this further. A measurement was not conducted.

115V mains voltage test (Rev. 0)

The test was conducted with the switchable version of the power supply (Version A), which was connected to an adjustable isolating transformer (Figure 6).

Figure 6: Adjustable isolating transformer

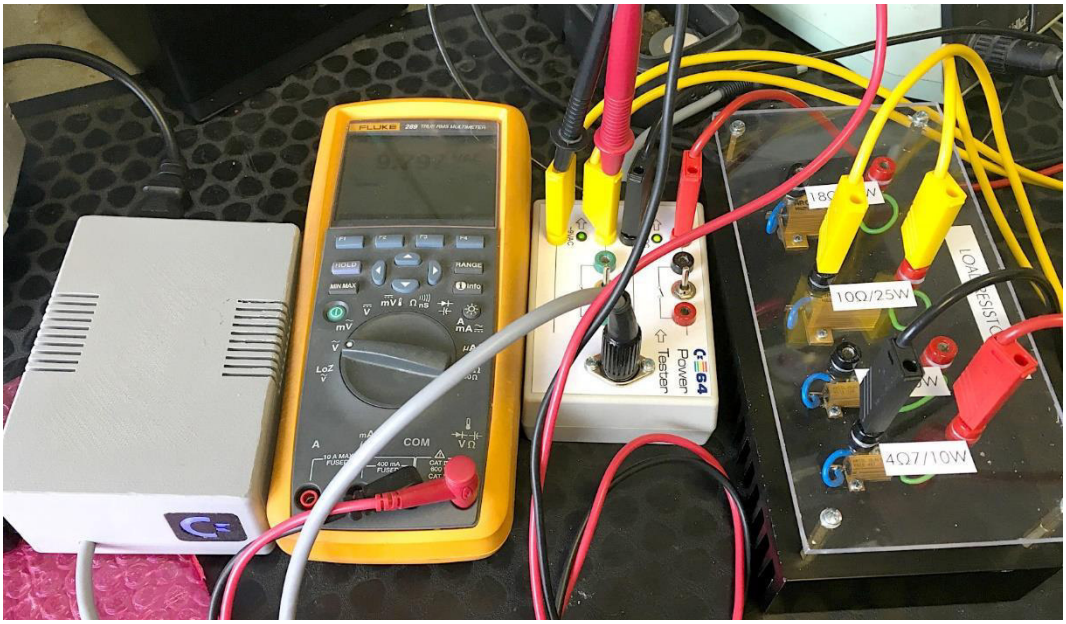


Figure 7: Test Setup for the 115VAC mains test

The isolating transformer was adjusted to approximately 110V. As expected, the +5VDC reading did not differ from the reading at 230V mains voltage. The 9VAC showed 9.8VAC with a 10Ω load. This test was also a proof of concept for the mains voltage selector switch.

Figure 8: Dim power switch

At 110VAC, the illuminated power switch was not bright at all (Figure 8). This was expected, since the switch was designed for 230V. This is not harmful, but as a conclusion, **for 115V, an illuminated switch is not required.**

Thermal Tests (Rev. 0)

The thermal behavior of the PSU Global might be critical, so this was investigated in depth. The critical temperature of PLA is 55°C to 60°C (when it softens) depending on the type. Since it was a goal to stay away from the critical temperature, it was repeated several times with modified cases. First, more ventilation slots were added in a second step the case has been made higher to get farther away from the transformer, which turned out to radiate most of the heat. A significant difference could not be achieved with the modifications of the case, though.

The temperatures were measured with a thermo couple positioned in the middle of the top shell right above the transformer and the (5V) AC/DC converter (Figure 9).

Figure 9: Position of the thermo-couple

The voltages were loaded with 4.7Ω on +5V and 10Ω on 9VAC and the temperatures were documented over the course of the test.

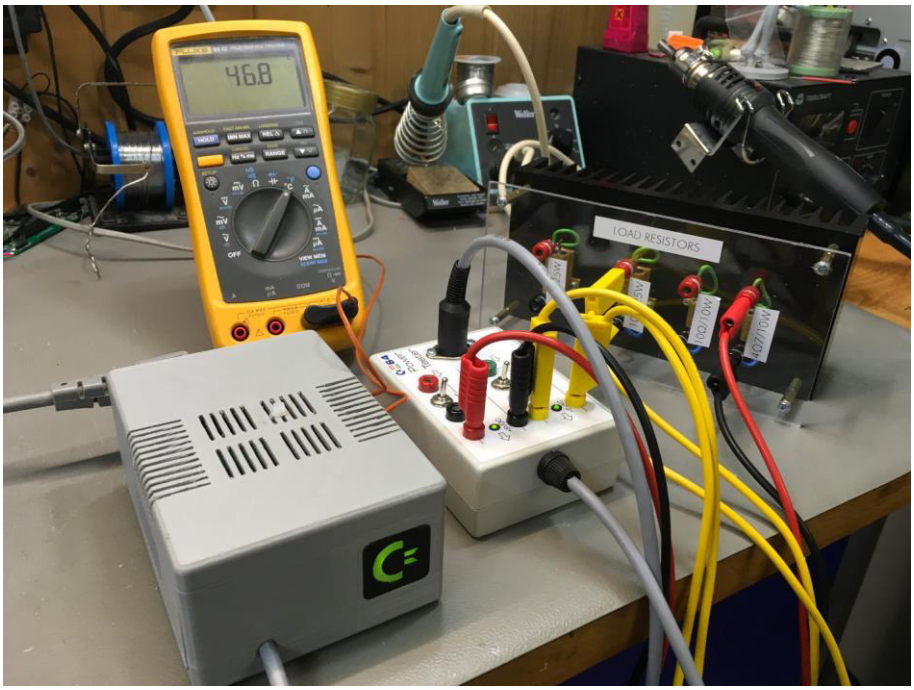


Figure 10: Test Setup (resistor load)

Measurement	#1	#2	#3
Time	0:00h	0:28h	2:16h
Temperature	22.2°C	34.1°C	46.7°C

In a second test, a real-life setup was tested. The highest current consumption is attained with an ASSY250407 C64. Further, an Ultimate II+ and a control port switch were connected to this computer. The temperatures were measures with the same setup like before.

Measurement	#1	#2	#3	#4
Time	0:00h	0:54h	1:49h	2:29h
Temperature	22.7°C	39.3°C	42.5°C	43.5°C

Conclusion of the temperature measurements: With the resistor load, the temperature rises to about 8°C below the lowest critical temperature (55°C) defined before. The ambient temperature was about 22°C. Thus, at an ambient temperature of 30°C, the critical temperature is reached.

With a real-life load, the temperature stays 11°C below the 55°C (ambient temperature 23°C). Thus, the critical temperature is reached at an ambient temperature of 34°C.

The critical temperature for the electronic components inside is 70°C, which is by far not reached.

Recommendation: do not use the power supply at an ambient temperature of >30°C if the case is made from PLA or use ABS for printing, which has a much higher critical temperature.

Figure 11: Real-life thermal test setup

Conclusion

Both, Rev. 0 and Rev. 1 are functional. The smaller voltage-drop of Rev. 1 is a small improvement. The case should be printed with ABS for an improved temperature range.

The all tested C64 were working without any problems while powered. Note: the original C64 PSU was set to about 5.2V or 5.3V. It is not sure, if this was really required or just a precaution. The AC/DC module used for this project is used for other C64 PSUs, too. It cannot be adjusted to a higher output. Its output is 5.00V. It might be possible, that a few C64s, which work perfectly with the original power supply do not work with this PSU (or any other, that uses AC/DC modules). In this case, it might be interesting to replace the fuse with a higher rated fuse (the AC/DC modules have an overload protection) and keep the output cable as short as possible.

C64 PSU GLOBAL Rev. 1
Bill of Material Rev. 1.0

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
1	1	133-2-01-00	2 Layer	PCB Rev. 0	2 layer, Cu 35µ, HASL, 90.0 x 84.0, 1.6mm FR4
2	1	22-27-2031	6410-3P	J4	optional (for **panel meter**): Molex 6410/22-27-2031 (KK, 2.54mm, 3p), e.g. Reichelt: MOLEX 22272031, tme.eu: MX-6410-03A
3	1	22-01-3037		(J4)	crimp housing, optional (for **panel meter**), Molex. E.g. Reichelt: MOLEX 22013037, tme.eu: MX-22-01-3037
4	3	08-50-0114		(J4)	crimp terminal, optional (for **panel meter**), Molex. E.g. Reichelt: MOLEX 8500114, tme.eu: MX-0850-0114
5	1	6.3 x 0.8	FLA6,3	J7	optional PE connector, PCB mount spade connectors
6	1	1x3p, 2.54mm	1X03	J6	standard pin header, 2.54mm pitch
7	1	dupont housing, 3p		(J6)	ebay, AliExpress or other
8	2	dupont terminals, female		(J6)	ebay, AliExpress or other
9	1	LED, blue		(J6)	Power LED, blue (R1 is calculated for blue)
10	1	2x2p, 2.54mm	2X02	JP2	standard pin header, 2.54mm pitch
11	1	2x3p, 2.54mm	2X03	JP1	standard pin header, 2.54mm pitch
12	5	jumper, 2.54mm		(JP1), (JP2)	standard jumper (rated 1A or more). E.G. Reichelt: JUMPER 2,54 SW, tme.eu: 63429-202LF
13	1	26604020	SPOX_3.96_2P	J5	optional (for **panel meter**): Molex SPOX, e.G. Reichelt: MOLEX 26604020, tme.eu: MX-26-60-4020
14	1	09503021		(J5)	crimp housing, optional (for **panel meter**): Molex. E.g. Reichelt: MOLEX 9503021, tme.eu: MX-2139-2A
15	2	08500106		(J5)	crimp terminal, optional (for **panel meter**), Molex. E.g. Reichelt: MOLEX 08500106, tme.eu: MX-2478-1-P913L (= 10 pack)
16	1	26604040	SPOX_3.96_4P	J3	Molex SPOX, e.G. Reichelt: MOLEX 26604040, tme.eu: MX-26-60-4040
17	1	09503041		(J3)	crimp housing: Molex. E.g. Reichelt: MOLEX 9503041, tme.eu: MX-2139-4A
18	4	08500106		(J3)	crimp terminal, Molex. E.g. Reichelt: MOLEX 08500106, tme.eu: MX-2478-1-P913L (= 10 pack)

C64 PSU GLOBAL Rev. 1
Bill of Material Rev. 1.0

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
19	1	26604050	SPOX_3.96_5P3	J1	Modification: Remove Pin 2 and Pin 4. Molex SPOX, e.G. Reichelt: MOLEX 26604050, tme.eu: MX-26-60-4050
20	1	09503051		(J1)	crimp housing: Molex. E.g. Reichelt: MOLEX 9503051, tme.eu: MX-2139-5A
21	3	08500106		(J1)	crimp terminal, Molex. E.g. Reichelt: MOLEX 08500106, tme.eu: MX-2478-1-P913L (= 10 pack)
22	2	0031.8211	318211	F1, F2	Schurter fuse holder (5x20mm). E.g. Reichelt: PL OGN-25, tme.eu: 0031.8211
23	1	5x20mm, 1.6A		(F1)	Fuse for 9VAC
24	1	5x20mm, 2A		(F2)	Fuse for 5VDC
25	1	100n	C-2,5	C1	Ceramic Cap, 50V, pitch 2.5mm
26	1	10321041	SPOX_5.08_4P	J2	MOLEX, option: **115V/230V** switch, tme.eu: MX-5281-04A
27	1	10013046		(J2)	MOLEX, option: **115V/230V** switch., tme.eu: MX-5197-04, Farnell: 2612656 , Mouser: 538-10-01-3046 , Digikey: WM9124-ND
28	4	08701031		(J2)	Molex Crimp terminal, option **115V/230V**, Farnell: 2060658, rs-online.com: 670-6265, Mouser 538-08-70-1031-CT, Digikey: WM18820CT-ND
29	1	T22205B436B		(J2)	Bulgin, option **115/230V** (switch), tme.eu: AE-T22205B
30	1	10n/500V	C-5	C3	Ceramic Cap, **500V**, pitch 5mm, Reichelt: KERKO-500 10N, tme.eu: CCH-10K (=10 pack)
31	1	1M	R-10	R2	Resistor, metal film, 5% or better, 0,6W
32	1	1N5908	CB429	D2	5V TVS diode. ST Micro. E.g. Reichelt: 1N 5908, tme.eu: 1N5908
33	1	47u/50V	C07/2,5	C2	el. Cap, 105°C, diameter 7mm, pitch 2.5mm
34	1	50R	R-10	R1	Resistor, metal film, 5% or better, 0,6W, calculated for blue led. For red, green, yellow: 330R. For **illuminated logo**: 0R!
35	1	B32922C3334M	C-18X8-RM15	C4	X2-capacitor, 330n, 305V, EPCOS. E.g. Reichelt EPCO B32922C3334, tme.eu: B32922C3334M

C64 PSU GLOBAL Rev. 1
Bill of Material Rev. 1.0

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
36	1	BV UI 304 0153	UI30	TR1	Hahn transformer, **option 115V/230V**, tme.eu: BVUI3040153
37	1	MPM-10-5	MPM10	M2	Mean Well, +5V@10W AC/DC module. tme.eu: MPM-10-5, Digikey: 1866-3459-ND, Farnell: 3002904, Mouser: 709-MPM10-5. Alternative for M1.
38	1	P6KE15CA	CB417NP	D1	15V bi-dir TVS diode, ST Micro, e.G. Reichelt: P6KE 15CA, tme.eu: P6KE15CA
39	1	RAC10-05SK/277	RAC10-K/277	M1	RECOM, +5V@10W AC/DC module. Tme.eu: RAC10-05SK/277, Digikey: 945-3121-5-ND, Farnell: 2822839, Mouser: 919-RAC10-05SK/277. Alternative for M2.
40	1	TEZ10/D230/9V	TEZ10	TR2	BREVE TUFVASSONS transformer, **option 230V only**, tme.eu: TEZ10/D/9V
41	1	6200.2300			Schurter, tme.eu: 6200.2300. Mains connector with fuse.
42	1	1855.1108			Marquardt, tme.eu: 1855.1108, Reichelt.de: WIPPE 1855.1108. Illuminated mains switch for the 3D printed case. Non-illuminated switch: Marquardt 1858.1103, Reichelt: WIPPE 1858.1103, tme.eu: 1858.1103
43	7	2-520184-2			TE connectivity, tme.eu: 2-520184-2 or Reichelt RND 465-00067. Example for 6.3 x 0.8 spade terminals, red, fully isolated. Required to connect to the mains connector and switch.
44	1	MAS 70S			Hirschmann DIN plug 7pin, 262°. Reichelt: MAS 70S, tme.eu: MAS70SGR. Example for C64 power plug
45	0.5m	4x0.5mm²			Cable for output voltages. 4xAWG21
46	4	4.8 x 0.8, isolated, red, female			Blade receptacle, e.g. tme.eu: BM00148, Reichelt.de: RND 465-00508
47	1	6.3 x 0.8, isolated, red, female			Blade receptacle, e.g. tme.eu: , Reichelt.de: RND 465-00045
48	1	0.5A/T	20x5mm		Mains fuse
49	1	3D printed case			ABS

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Pos.	Qty	Value	Footprint	Ref.-No.	Comment
50	30cm	mains cable, 0.5mm² - 0.75mm²			To be salvaged for the mains cables
51	8cm	cable 0.5mm², red			for the 230V/115V version
52	8cm	cable 0.5mm², green			for the 230V/115V version
53	10cm	cable 0.25mm²/AWG24, red			
54	10cm	cable 0.25mm²/AWG24, black			
55	1	illuminated logo			see text
56	4	M3x10 (DIN 7985)			screw
57	8	M3, self-locking (DIN 985)			nut
58	4	M3x12 (DIN 965)			countersunk screw
59	2	C2.9x9.5mm (DIN 7981)			screw for sheet metal or plastic
60	4	C2.9x6.5mm (DIN 7982)			countersunk screw for sheet metal or plastic