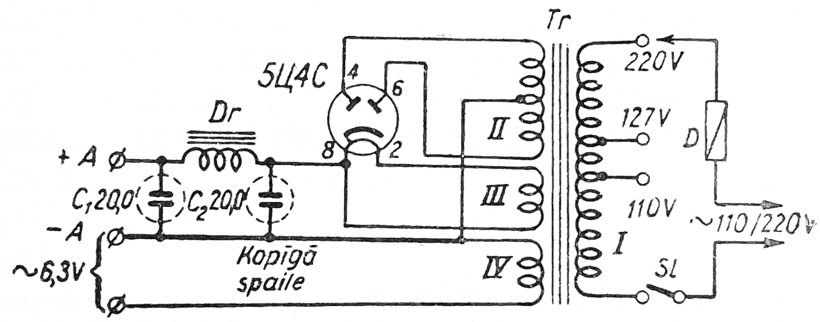
mki x es.edu
POWER SUPPLY UNIT (PSU) AND EURORACK CASE ASSEMBLY MANUAL

The **mki x es.edu project** takes you on a journey of building a complete, self-contained eurorack system. Those who are already into eurorack will find the mki x es.edu modules to be a nice addition to their existing systems, but those who are about to take their first steps into modular synthesizers will **need a reliable power supply unit (PSU) and eurorack-compatible enclosure**. You can find a lot of information online about DIY PSUs and enclosures; some nice projects are consolidated on the **modularsynthlab.com** blog or, for example, this one found on **instructables.com**.
I got into DIY electronics in the mid-80's when I sneaked into a physics class and "borrowed" a book called "Young Radio Amateur", published in the USSR in 1961. Most of the DIY projects described in the book were designs based on vacuum tubes and they required PSUs with output voltages up to 400V.



221. zīm. Praktiska principiālā shēma divu pusperiodu kenotrona taisngriezim.

High voltage is extremely dangerous and can be lethal (an electric chair for executions operates at 2000V), therefore, if you are newbie in electronics or a teacher who cares about the safety of your students (all teachers should care), **we do not recommend building PSUs that connect directly to mains** (wall) power outlets, even though some of the projects mentioned above use switching power supplies that convert mains power (110 – 230VAC) to eurorack **standard bipolar +-12V**.

Moritz has a nice video tutorial on a **DIY linear PSU for a eurorack system**, but it requires a rather hard-to-find AC/AC wall wart.

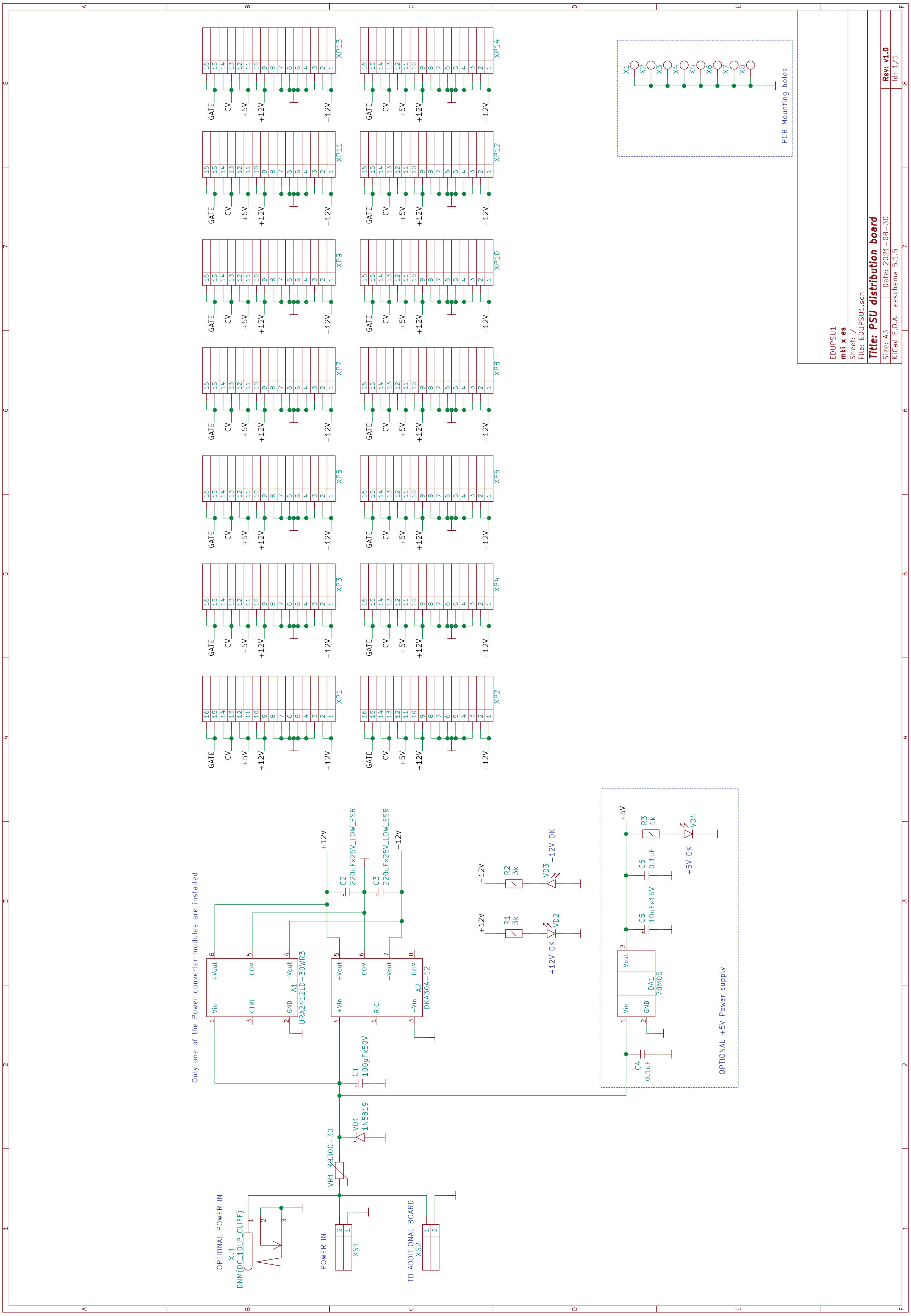
So, with all of the considerations above, we decided to design a **DIY eurorack PSU based on a DC/DC converter**. It turns +12VDC from a wall wart AC/DC adapter into eurorack standard bipolar +-12V. This ensures the voltage in your eurorack system never exceeds 12V and any area in your eurorack case is safe to touch. We use stock DC/DC converters (MORNSUN URA2412LD-30WR3) that are safe and reliable and have internal short circuit protection.

Each eurorack module comes with technical specifications and **its power consumption** (what current flows through the module from each +12V and – 12V rail when the module operates) is among those. When planning and building your eurorack system, you need to consider the **total power consumption** of all modules in your system. The best way to plan out your modular system is to design your virtual eurorack case on the “Facebook” of modular synthesizers – **www.modulargrid.net**. Navigate to the RACKS menu, choose the size of your eurorack case, populate it with modules and you will see the total power consumption of this potential eurorack system. Our mki x es.edu PSU has enough output power (1,25A on each rail) to power up to 4 complete mki x es.edu systems.

The mki x es.edu eurorack case/PSU DIY kit contains:
One row 84HP eurorack case,
AC/DC wall wart adapter with 12VDC output, max current is 1A,
DC socket and power switch,
mki x es.edu PSU PCB,
DC/DC converter,
14 2x8 pin sockets for eurorack power cables,
All components to complete the PSU.

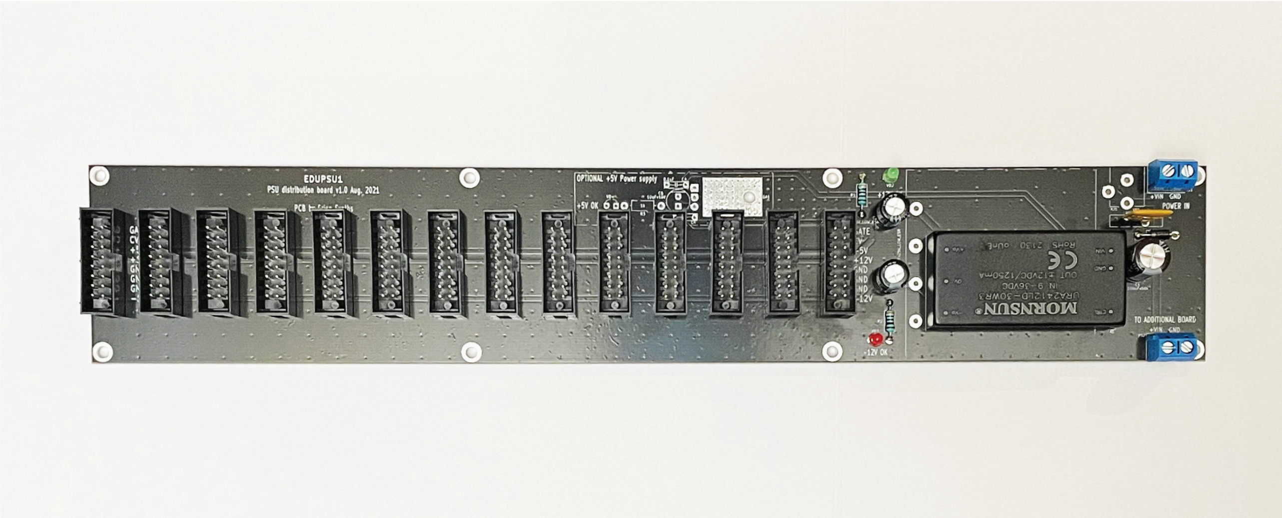
Please note that in order to reduce the overall cost of the case we do not use eurorack rails with threaded inserts or sliding nuts, instead, there are pre-drilled, threaded holes to accommodate the modules of the **mki x es.edu system in a specific order**. If you intend to use this case for other modules than mki x es.edu series, make sure you have a 2.5mm drill and a tap for an M3 screw thread, so you can drill threaded holes for modules of various widths.

Now, let’s take a look at the **mki x es.edu PSU** schematics!

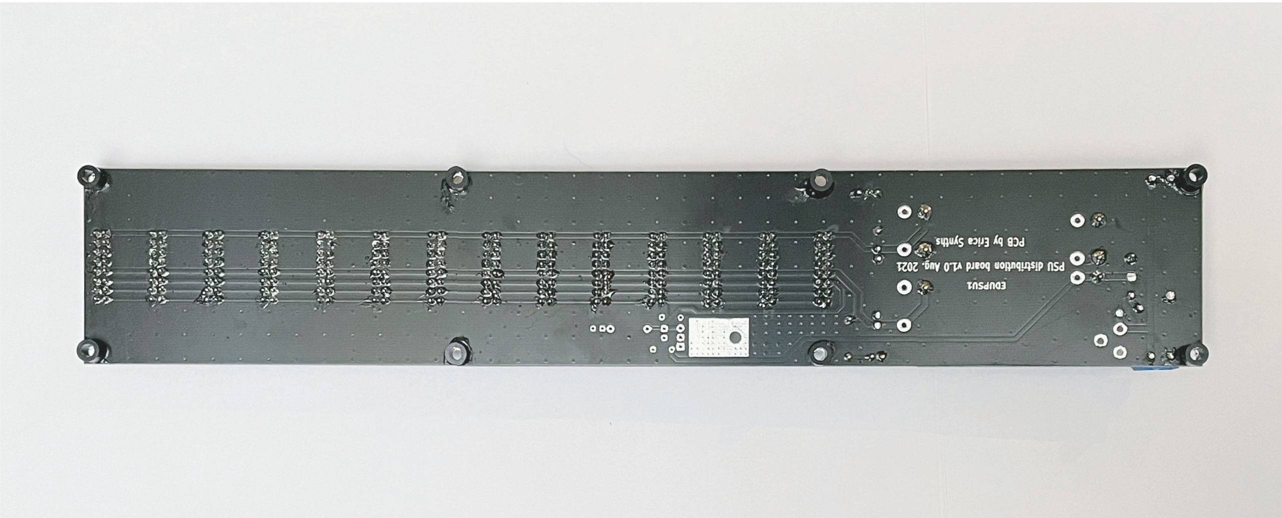

EDUPSU1
mki x es
Sheet: /
File: EDUPSU1.sch
Title: PSU distribution board
Size: A3
Date: 2021-08-30
KiCad E.D.A. eeschema 5.1.5
Rev: v1.0
Id: 1/1
PCB Mounting holes
Only one of the Power converter modules are installed
URA2412LD-30WR3
DKA30A-12
220uFx25V_LOW_ESR
100uFx50V
VR1 PB300-30
VD1 1N5819
OPTIONAL +5V Power supply
DA1 78M05
10uFx16V
0.1uF
+12V OK
-12V OK
+5V OK
OPTIONAL POWER IN
XJ1
DNM(DC-10LP_CLIFF)
POWER IN
XS1
TO ADDITIONAL BOARD
XS2
GATE
CV
+5V
+12V
-12V

XS1 is a socket for the +12VDC input. XS2 is an optional socket in case you want to connect several PSU boards in parallel.
VR1 is a resettable fuse – in case there's an accidental short circuit somewhere on the PCB or the input voltage is connected in reverse, the fuse will cut the circuit immediately. As soon as the problem is eliminated, the fuse will automatically reset and allow for current flow in the circuit.
VD1 is a **Schottky diode** that secures reverse polarity power supply protection. In this case it works in junction with the resettable fuse VR1. Diodes pass current only in one direction. Because the cathode of VD1 is connected to +12 V and the anode to GND, it does not pass current through and normally it will not have any effect whatsoever on the circuit. If a negative voltage, however, is accidentally applied to XS1, the diode starts to conduct the current and essentially makes a short circuit between the XS1 lugs. A short circuit means the current in the circuit tends to increase rapidly and this is where the resettable fuse kicks in – as soon as the current reaches 3A it breaks the circuit.
The capacitors C1-C3 serve as energy reservoirs that keep power supply voltages stable in case there are any fluctuations in the power consumption of certain modules (e.g blinking LEDs) in a modular system.
Light emitting diodes (LEDs) VD2 and VD3 are "voltage ok" indicators for both the +12V rail (VD2) and the -12V rail (VD3). They are connected in series with current-limiting resistors R1 and R2, respectively. LEDs are designed to operate in a certain current range (the more current flows through an LED, the brighter it shines), but there's certain maximum current that an LED can handle, so limiting resistors are required. The anode of VD2 is connected to the +12V rail through R1 and the cathode – to GND. If there is +12V on the rail, a current will flow through R1 and VD2 (remember, diodes pass a current in one direction only and the same goes for LEDs) and VD2 will light up. Same goes with the VD3 on -12V rail. If something goes wrong and there's no 12V on the rail, the LED will be off or half dimmed – this typically happens when modules are connected incorrectly in reverse polarity or they are defective.
XP1-XP14 are 2x8 pin power supply connector sockets with keys to prevent reverse polarity connection. In eurorack standard, PSU boards have 2x8 pin connectors and each pair of pins serves a specific function. It's described well on the modular manufacturer's **Noise Engineering blog**.
A small **schematic around DA1 is for an optional +5V power supply** (parts are not included in this kit) built around a DC linear voltage regulator (often referred to as a low-dropout regulator or LDO) 78M05. Some eurorack modules require an external +5V supply and as you saw from the connector pinout above, there are dedicated pins for +5V. Our mki x es.edu modules do not require a +5V supply, therefore this part of the schematics is optional.
Now, let's start assembling the PSU and the mki x es.edu eurorack case!

The PSU assembly is straight-forward – just solder all of the components on the PCB according to the silkscreen. **Mind the orientation of capacitors** (a notch on the silkscreen must match the negative lead of a capacitor), **LEDs and PSU sockets.** Once completed, your PCB should look like this:

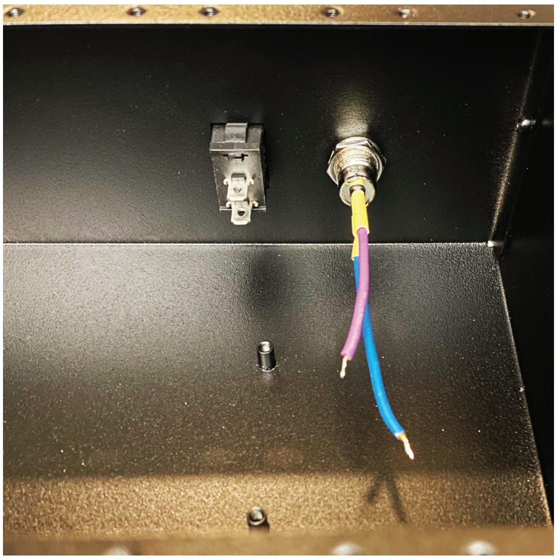


Now, turn the PCB around and **check the quality of your soldering.** Make sure there are no accidental shorts and that all solder joints are nice and clean.

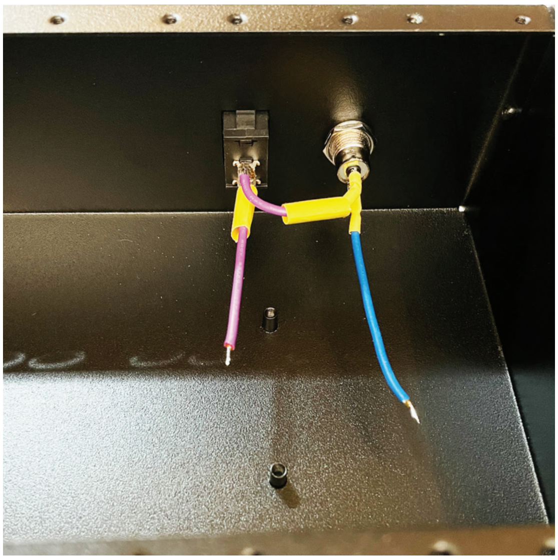


Next step – **prepare a DC socket.** For a better solder joint, use a file to clean the chromium coating from the socket lugs and increase the temperature setting on your **soldering iron to 400°C**. Solder two wires to the lugs as shown in the picture below:

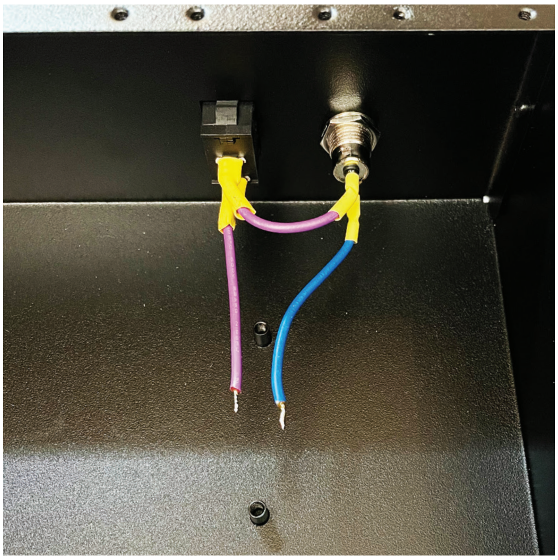
For safety, use small pieces of **heat shrink tubes to insulate solder joints** and heat them with a lighter to make them shrink around the lugs:



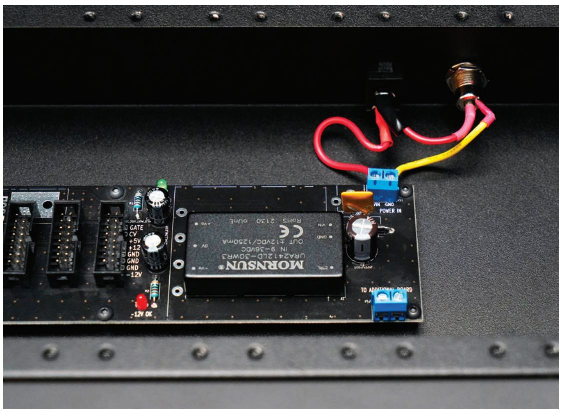
Now, fix the socket into the case and use pliers to tighten the hex nut. Also, insert a **power switch** in the rectangular hole:



Solder the longer wire to the bottom lug of the switch. Then, put a heat shrink tube on the shorter wire and solder its end to the top lug of the switch.



Now, use a lighter to heat the tubes, so they **shrink around the switch lugs**.



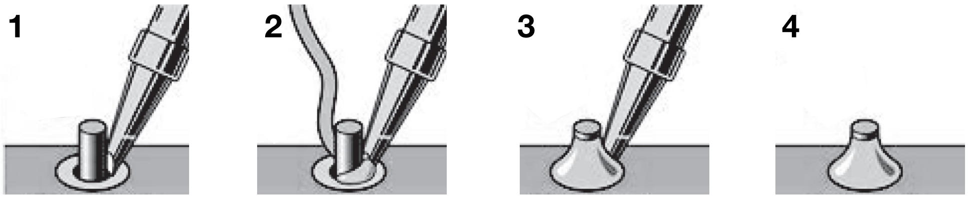
Insert the PSU board in the case and fix it with 8 screws. Connect two wires to the socket XS1. Mind the connection polarity – the wire from the switch goes to the **+VIN lug** and the wire from side lug of the DC socket goes to the **GND lug**.

Congratulations! You have completed the assembly of the DIY case! Connect an AC/DC adapter to the DC socket and flip the ON switch. Both LEDs should light up. If they do, **measure voltage between the GND pins on the eurorack power connector and the -12V pins**. Make sure you read about -12V. **Then continue with +12V.** If the readings are ok, you can start populating your newly built eurorack case with modules!

SOLDERING APPENDIX

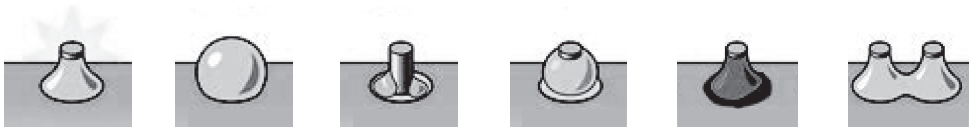
If you've never soldered before – or if your skills have become rusty – it's probably wise to check out some **THT** (through-hole technology) **soldering tutorials on YouTube**. The main thing you have to remember while soldering is that melted solder will flow towards higher temperature areas. So you need to make sure you apply equal heat to the component you are soldering and the solder pad on the PCB. The pad will typically absorb more heat (especially ground-connected pads which have more thermal mass), so keep your soldering iron closer to the pad on the PCB. It's critically important to dial in the right temperature on your soldering station. I found that about 320 °C is the optimal temperature for most of parts, while for larger elements like potentiometers and sockets, you may want to increase that temperature to **370 °C.**

Here's the recommended soldering sequence:



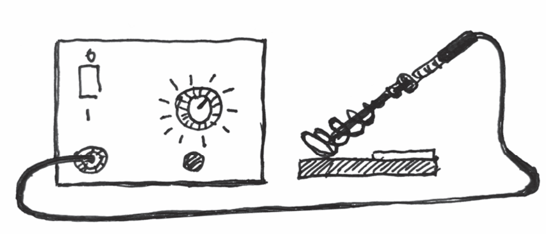
Heat part and pad 2 - 3 sec | Add solder | Continue heating 1 -2 sec. | Let cool

After you have completed soldering, inspect the solder joint:

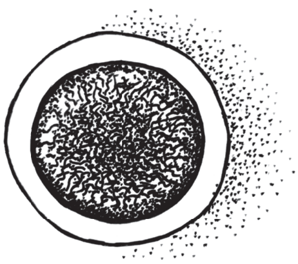


Perfect | Too much solder | Not enough solder | Cold joint | Too much heat | Short

DIY electronics is a great (and quite addictive) hobby, therefore we highly recommend you invest in good tools. In order to really enjoy soldering, you'll need:

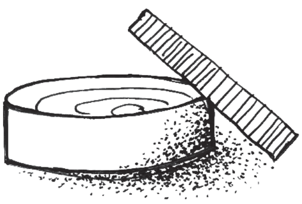


A decent soldering station. Top-of-the-line soldering stations (brands like Weller) will cost 200€ and above, but cheaper alternatives around 50€ are often good enough. Make sure your soldering station of choice comes with multiple differently-sized soldering iron tips. The most useful ones for DIY electronics are flat, 2mm wide tips.



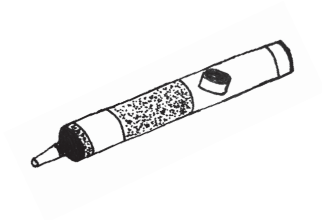
When heated up, the tips of soldering irons tend to oxidize. As a result, solder won't stick to them, so you'll need to clean your tip frequently. Most soldering stations come with a **damp sponge for cleaning the iron tips** – but there are also professional solder tip cleaners with **golden curls** (not really gold, so not as expensive as it sounds). These work much better because they do not cool down the iron.

Solder wire with flux. I find 0,7mm solder wire works best for DIY projects.

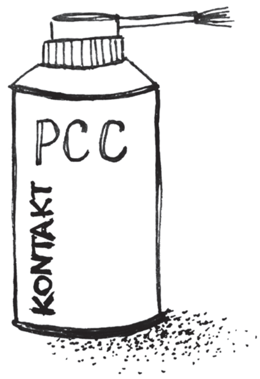


Some **soldering flux** paste or pen will be useful as well.

Cutting pliers. Use them to cut off excess component leads after soldering.



A solder suction pump. No matter how refined your soldering skills are, you will make mistakes. So when you'll inevitably need to de-solder components, you will also need to remove any remaining solder from the solder pads in order to insert new components.



Once you have finished soldering your PCB, it's recommended to remove excess flux from the solder joints. **A PCB cleaner** is the best way to go.

All of these tools can be found on major electronic components retailer websites, like Mouser, Farnell and at your local electronics shops. As you work your way towards more and more advanced projects, you'll need to expand your skillset and your tool belt – but the gratification will be much greater.

“We keep moving forward, opening new doors, and doing new things, because we're curious and curiosity keeps leading us down new paths.”

– Walt Disney