# Construction notes modular tester rack

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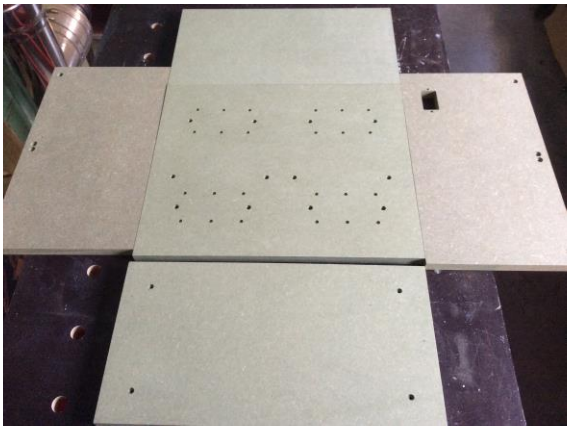
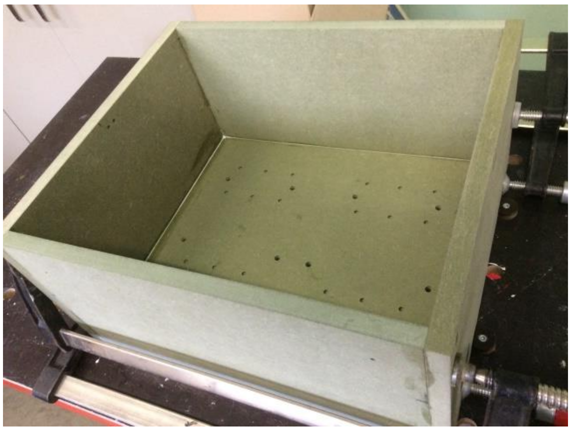
**Disclaimer:** these notes are a guidance on how you can build this rack, it is a DIY project, not a kit nor a full step by step guide. I am not responsible for what you build or how you use it. You can build this as is or use it as inspiration for your own projects. A decent knowledge of electronics is assumed.

Cabinet is constructed in 18mm green MDF including the back panel, milled on a CNC for precise placement of holes, green MDF because it is more compressed and has cleaner edges when milled or cut.



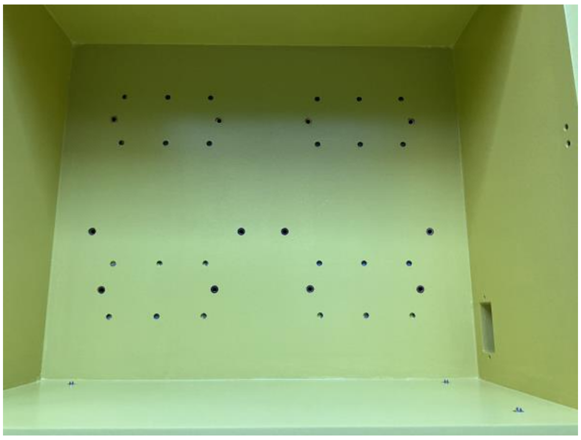
Put together with lamello's and wood glue.



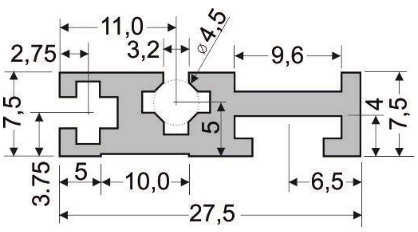
Edges rounded on a router table with a roundover bit.

Brush filler on the edges, layer of primer and two layers of satin paint. Of course lots of sanding.


4mm threated inserts in blind mounting holes for power supplies and distribution backplanes (12 in total).



The cabinet is dimensioned to use a standard length profile of 432mm, 4 pieces are used. Brand is Gie-Tec and type is “19″-Mounting Profile2” (432mm unperforated) (website https://gie-tec.de/).

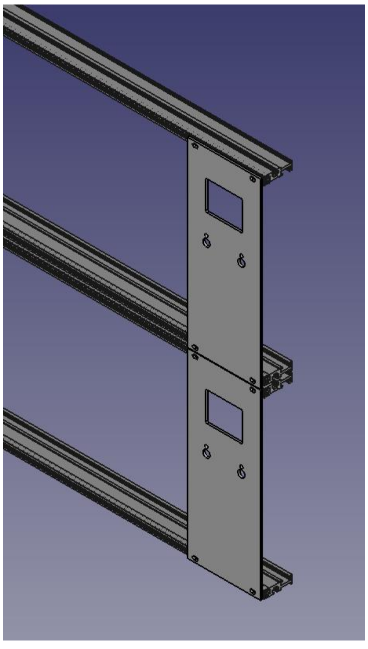



Threaded strips are inserted in the front T-slot, Gie-Tec “steel threaded strips M3, l = 426.7mm, pitch 5.08”.

The strips are threaded for M3, spacing is in inches to match the dimensions of popular rack types.

Profiles are fixed with stainless steel screws with a large area low profile head M5 x 30mm. They will thread themselves into the profile, no need to pre-thread the profile ends. Holes in the cabinet are recessed to allow the heads to be countersunk.

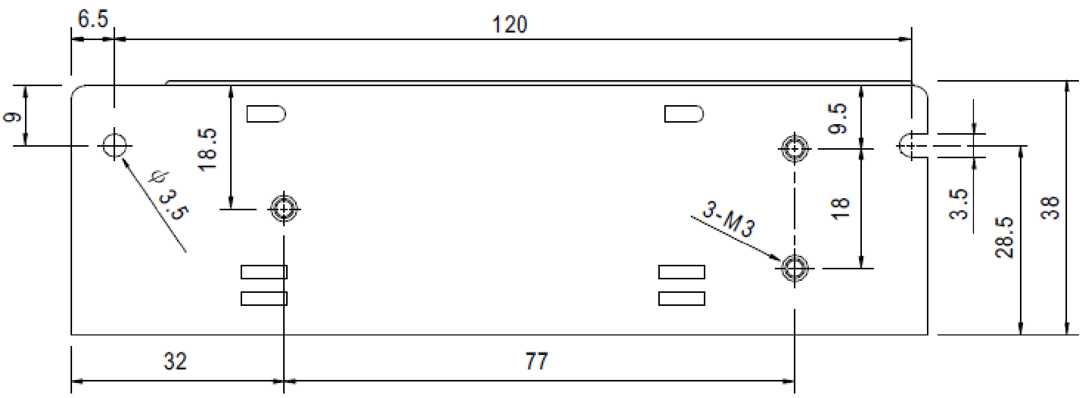
Note that the mounting hole is not in the center of the profile, mount top and bottom profile with the large T-slot facing away from top or bottom plate, the middle ones with the T-slot facing the opposite profile.



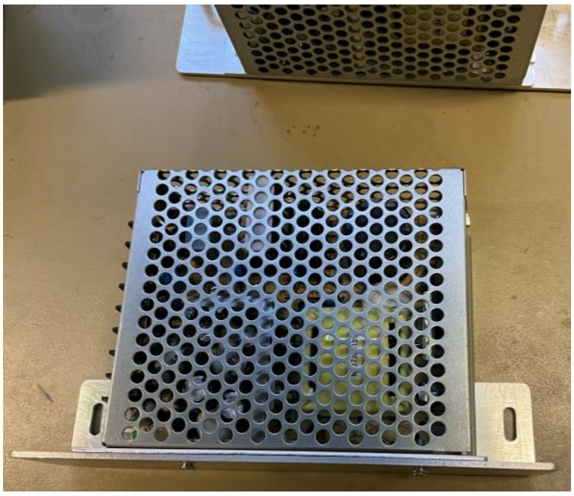
As height 4U is selected (as used in Serge and Buchla racks), with a little margin front panel height is 177.4mm. This allows enough space for display, controls and connections.

Width of modules can vary (in increments of 5.08mm), I selected 14HP as general module width, with a little margin module width is 70.8mm. This allows 6 modules per row, 12 per rack.

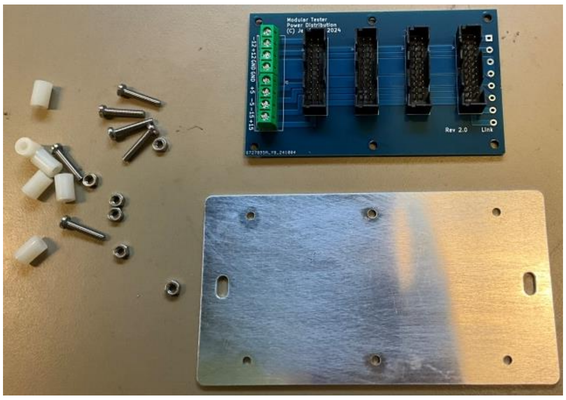
Power supplies (1x Meanwell RQ-65B and 1x Meanwell RQ-65C) are mounted on a 2mm aluminum CNC milled folded frame, secured with 3 M3*5 screws on the bottom as per drawing in the datasheet. Tip: write the details on the other side since the label will be covered.







4 power distribution backplanes are mounted on a 2mm aluminum CNC milled plate, the MDF back plate has recessed holes to allow the M3 screw heads, PCB mounted with M3x16mm screws and 10mm nylon standoffs, mount with nuts on the top side.




4x 10mm high rubber feet are mounted on the bottom with M4 screws, washers and nuts, heads recess in the bottom plate.

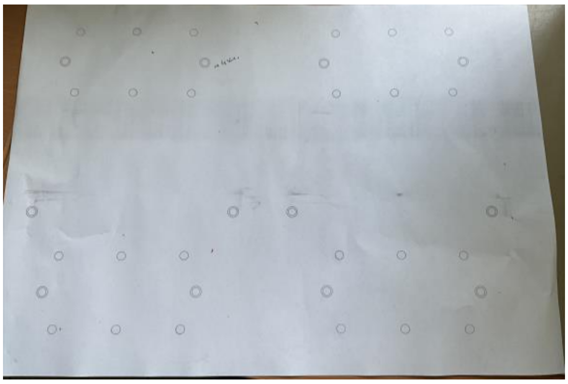
Two power supplies are used, Meanwell RQ-65B and RQ-65C, one has +5V/-5V/+12V/-12V, the other +5V/-5V/+15V/-15V, providing a large range of voltages to the modules.

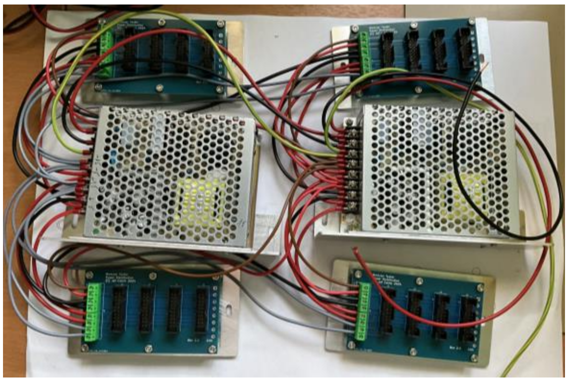
The power supplies are wired as follows: +5V / -5V: distributed one PSU for left backplanes and one PSU for right backplanes. Other voltages to all backplanes.

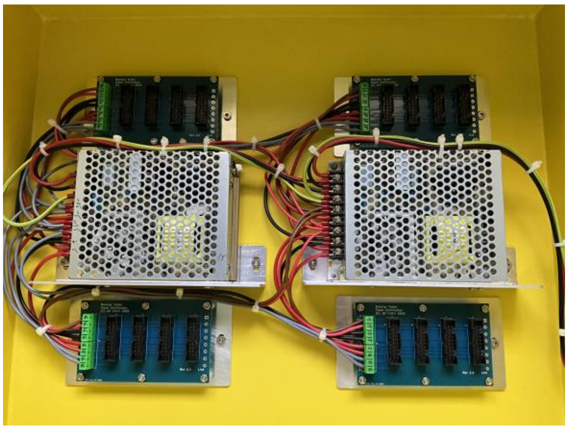
Provisions are made on the PCB to link through but this is not used for now.

To wire it all up print the back design and layout the modules on it, connect the wires, then transfer to the cabinet and add tie wraps.

Use sensible wire gauges, I used 1.5mm2 for mains and 5V lines, 0.75mm2 for other voltages.







Primaries of both PSU’s are wired to the mains entry with integrated fuse and power switch.


Modules connect to the power distribution backplanes with a 20cm ribbon cable with 20 pin IDC connectors.

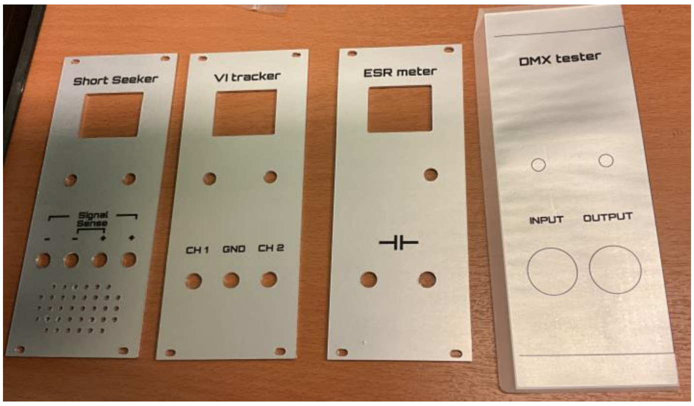
Two 35cm long cables are made to place the modules outside the rack for development, measurements or calibration (the VI tracker needs 2 cables) and to place the last module since you then cannot reach inside to connect when all modules are installed.

All aluminum parts are CNC milled in 2mm aluminum.

Labels are made in Inkscape, outside rectangle is a little larger to allow cutting and positioning, this is later trimmed. Templates provided are the preparation version with all details and final version with a larger edge and removed details. Common holes for the encoders are printed and cut out to use for label positioning.

Labels are printed with a laser printer on heavy duty silver labels “Avery Zweckform L6013-20”, 4 fit on one sheet.

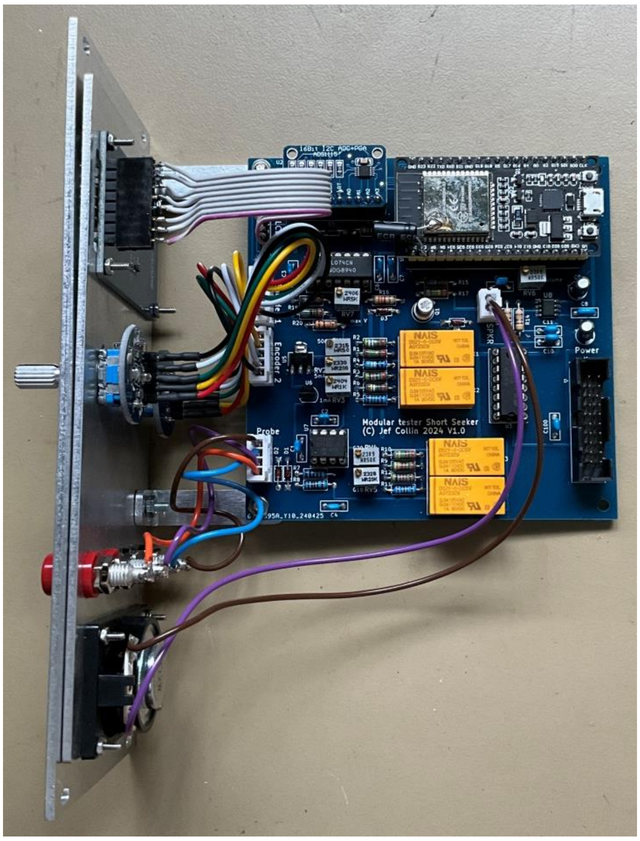
The uncut printed label sheet is laminated using matte 80 micron laminating pouches, I put a sheet of scrap paper on the back while laminating so there is no laminate on the backing sheet making it easier to remove.




Labels are stuck on the front panels and holes cut out with a scalpel. Note that the adhesive is very strong, once you touch the metal with the foil, it sticks very hard, no second try.

The module concept has 4 elements:

1- the front panel with holes for the display, controls and connections and 4 slotted holes to fix it to the rack in a 5.08mm spacing
2- a sub frame with mounting holes for display, controls and other parts like speakers, I did not want the screws for these visible on the front panel
3- two angled brackets that attach to the sub frame, providing some spacing for the wiring and mounting of the PCB
4- the PCB (or multiple PCB's stacked on top of each other with spacers)



The PCB is mounted on the brackets with M3x16mm screws and 5mm nylon spacers. 4 holes are provided on the PCB as standard in case someone wants to mount them in a different way or to stack multiple PCB's in case of multiple board designs like the VI tracker.

PCB's are standardized to 101.6x101.6 mm or 4x4 inches, most parts are laid out in an inch grid and it takes optimal advantage of the JLCPCB special offer on sizes of max 102x102mm.

Mounting the PCB perpendicular to the front needs more depth but allows more components compared to a Eurorack module where the PCB is parallel to the front and includes all controls on the PCB taking away component space.

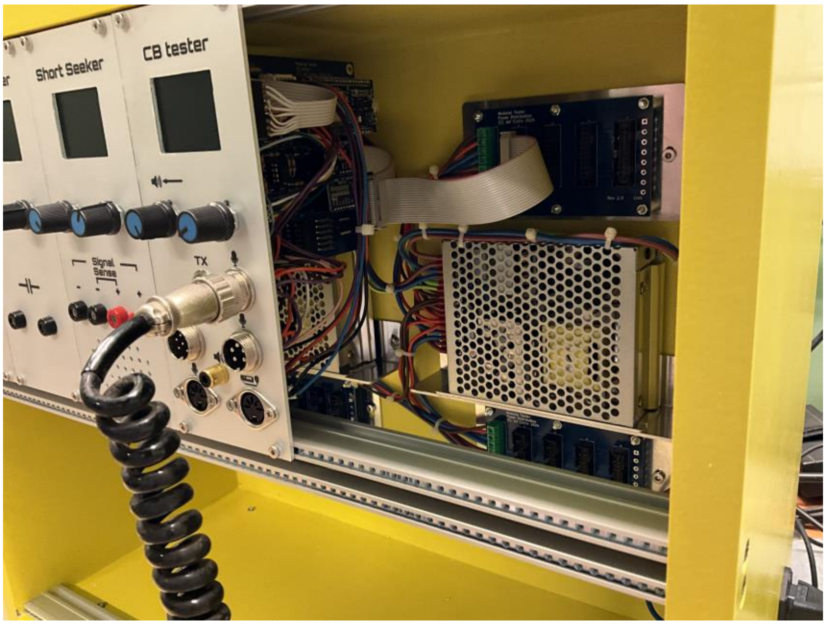
Display (M2 screws) and brackets (M3 screws) are mounted on the sub frame (countersunk head screws), holes can be a little countersunk but such small holes are difficult since aluminum is soft and material is rather pushed aside instead of removed and some supports are narrow, therefor just countersink a little bit by hand, space for the screw heads is provided later on by spacers.

The front and sub panels are sandwiched together, alignment is provided by common holes for the controls that are in both panels, thin M7 spacers (stainless steel available in many thicknesses, I use 0.2 and 0.5) are used in between to allow space for the display, bracket and speaker screw heads. The controls hold together both panels, the nuts on the controls will be covered by the knobs.

Modules are mounted in the cabinet with small M3x5mm screws with a hex head and a plastic M3 washer.

When completed it looks like this, some space behind the PCB’s. The flat cable should align with the backplane but I made a small error on my drawing, everything on the back panel should be positioned a little bit lower, this is corrected in the final drawings. No provisions are made for vent holes, usually one module is used at one time and heat given off by the PSU is minimal.

When powered on the modules show a splash screen and then go into sleep mode for power saving, a long push on the right rotary encoder wakes up the module. The module can be put to sleep again via its menu. Some modules have a power button.



Notes on the drawings

Drawings are made in Carbide Create 6.xx (free version), this is the software I use to generate G-code files for my DIY CNC router which uses MACH3, drawings can be exported as SVG files and printed in Inkscape or imported in other programs.

You can view the dimensions, positions etc in Carbide Create in case you want to recreate the panels by other methods.

Milling paths and settings are for the mills I often use, 3.175mm for the MDF and 2mm single flute for the aluminum.

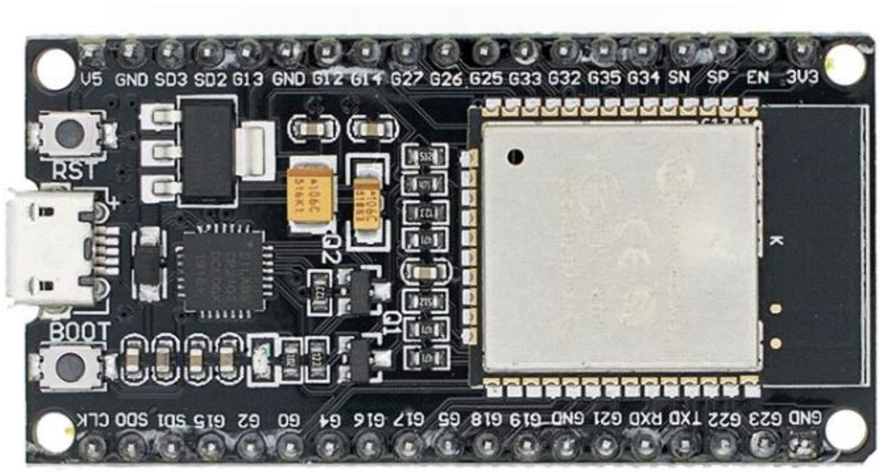
Parts with folds have a small indent milled in it allowing easy (manual) folding, indents are at the outside of the fold.

The MDF cabinet drawings use 18.3mm as thickness because that was the exact dimension of the sheet I bought. Because of these tolerances I designed the cabinet with top/bottom and back to exact inner width matching the profile lengths. Make sure you adapt the height of the back panel to your exact panel thickness because you need to keep the height of the sides (height = height of side panel – 2x panel thickness), make sure to distribute the changes on both sides so the holes are positioned correctly.

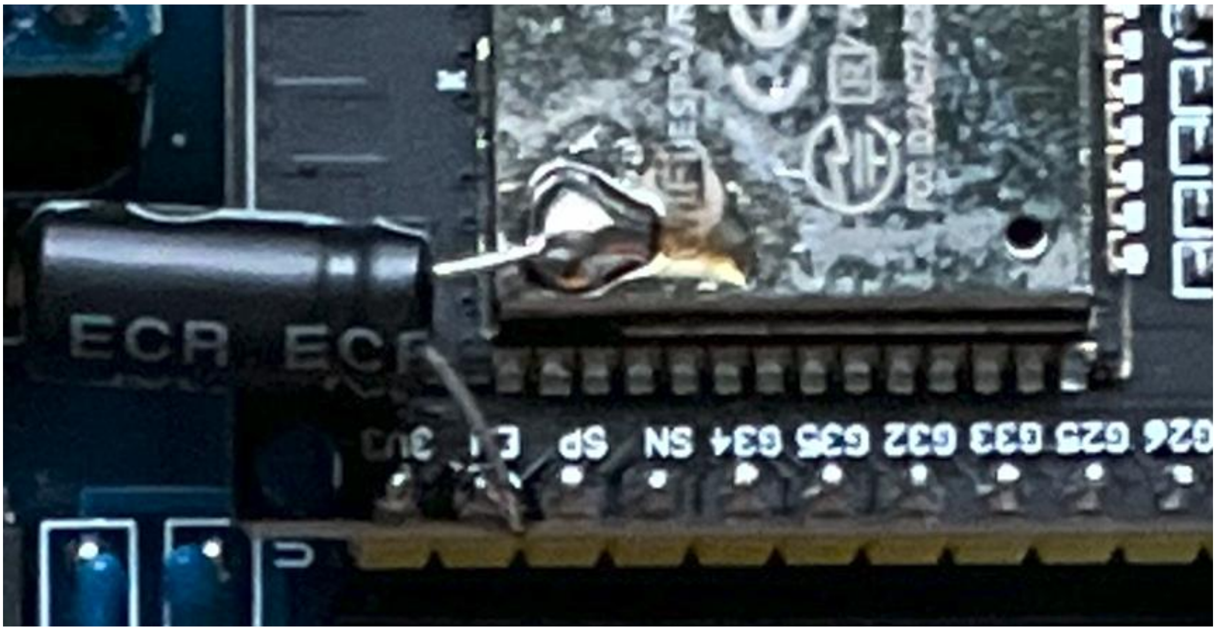
Notes on parts used

ESP32 module

I use the 38 pin variant of the DOIT DEVKIT WROOM-32 module, not the best choice since the extra pins are used internally and cannot be used but I bought and used lots of them and want to keep one standard, pick one and stick with it, they are only 4 EUR. Others will not fit but you can design a new PCB with your own choice of ESP32.

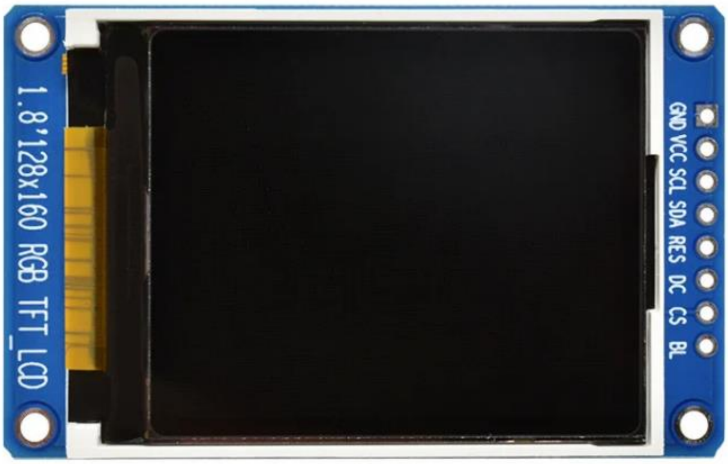


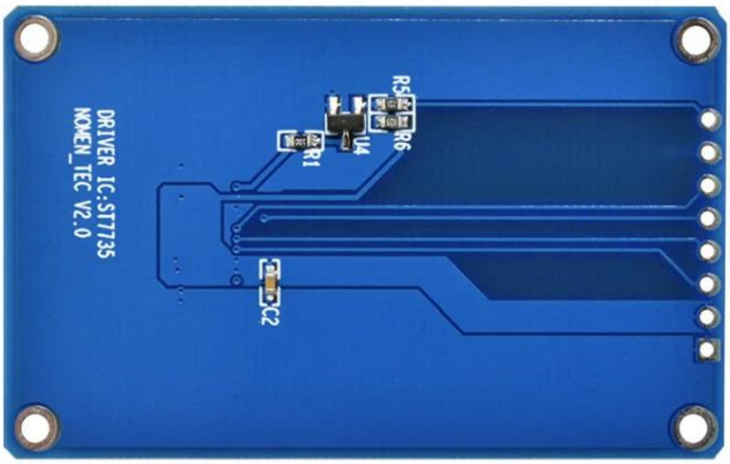
Default I make this well documented modification, adding a 10uF capacitor between EN pin (+ of cap) and ground (- of cap). This removes the need to press the boot button to download software with the Arduino IDE.




LCD display

I use these 1.8” modules with a ST7735 driver, resolution 160*128. Other displays can be used but require software and hardware redesign. The connections to the ESP32 are the same for all designs because it is fixed in the tft_espi configuration file, the backlight control might use different pins.



Rotary encoders

I prefer this type, it has the proper debouncing components on its own PCB, saving space on the module PCB.

These are available from several vendors but they seem to use a mix of brands and types for encoder switches, some have polarity reversed, in that case, reverse S1 and S2 or change pin assignment in the software.

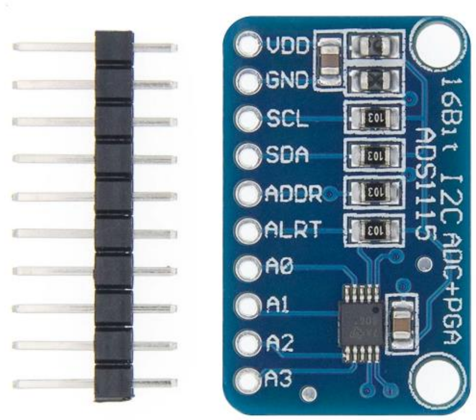
Encoders can have other number of steps, the software allows configuring in the source code, no libraries are used allowing tight control of encoder actions via interrupt routines and a state machine.

There is a pin labelled 5V but it connects to 3.3V, it’s just the power to the pull up resistors, do not power with 5V.

External ADC

In some designs I use standard modules like this analog/digital converter, the ADC in the ESP32 has a few flaws, it will not detect anything below 150mV and the top end is not linear, in some circuits I bias the signal halfway the range avoiding this issue.

In cases where I need more precision and/or low voltage signals I use this ADS1115 module.



Other parts

On the schematics, resistors are standard E12 series unless specified otherwise, E96 series metal film resistors will be indicated as 1%, wattage standard 0.25W unless specified otherwise.

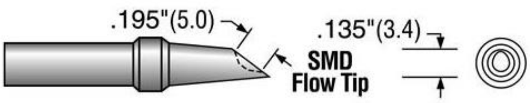
Capacitors, if no voltage is specified, use sensible voltage values in line with supplied voltages, in general non polarized caps are 50V and polarized caps have voltage mentioned. Of course take note of the polarization (+/-).

Specific parts have part numbers or additional info on the schematic.

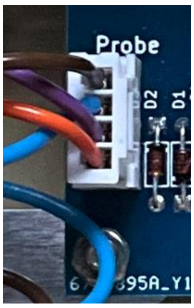
You see lots of relays in the designs, several reasons, one being that I have a few hundreds of this model in my stock.

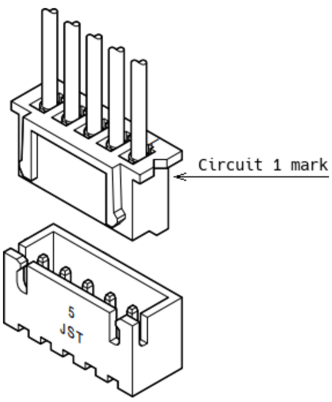
Same goes for some other components like the TL074, I might only use 1 of 4 opamps but I have many of them in stock.

I prefer to use through hole components, sockets for the IC’s, header strips as sockets for modules but some components are surface mount due to availability or space, this requires some skills to mount but it’s doable with a soldering iron with a good (hollow) tip and extra flux. I use a 30+ year old Weller station and a large Plato SMD flow tip, extra flux and in case of bridging pins “soder wick”. The hollow tips such as the Plato SMD flow tip or Wave tip / MiniWave tip for Pace stations draw the solder back onto it. Don’t use too much heat. Mount the SMD components first.

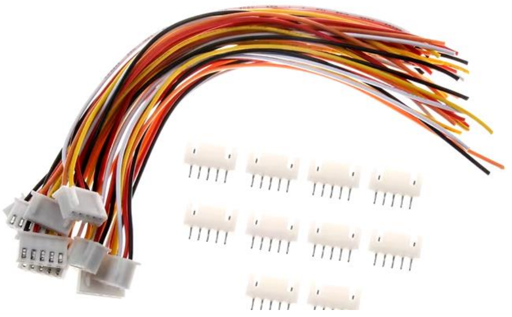



Connectors on the PCB’s are drawn as 2.54 mm pitch header or socket strips but in most cases JST XH type will fit allowing a choice of connections. A proper crimping tool is recommended for the XH connectors. Note the correct position of pin 1 (square pad on the PCB and notch in the connector).

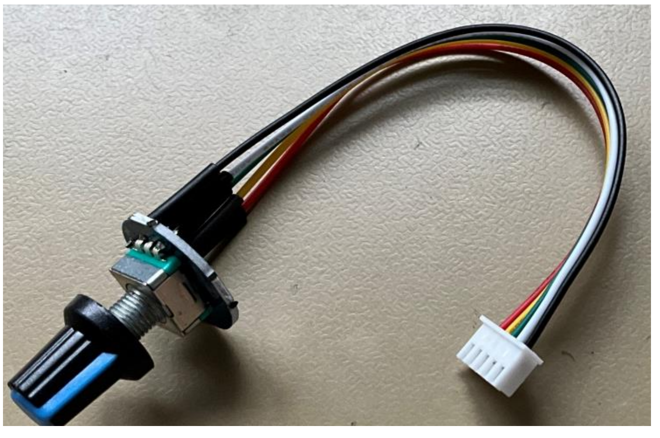


For the encoders and display I use premade XH 15 cm cables of 5 and 8 pin.

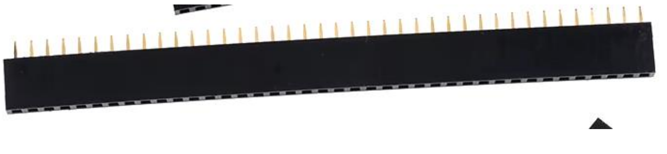


The 5 pin cables for the encoders are trimmed to 10 cm and black and red wires switched to color match + and GND on the encoder PCB (push the retainer hook in a little and pull the wires out). Wires are soldered directly to the encoder pin strip, heat shrink tubes are used.



The 8 pin cables for the LCD are trimmed to 9 cm, a 8 pin header strip is soldered on the other side, heat shrink tubes are used.

40 pin socket header strips 2.54mm can be cut to size for ESP32 sockets, ADC module sockets and LCD connection.



40 pin header strips 2.54mm are used when standard XH connectors are not available.