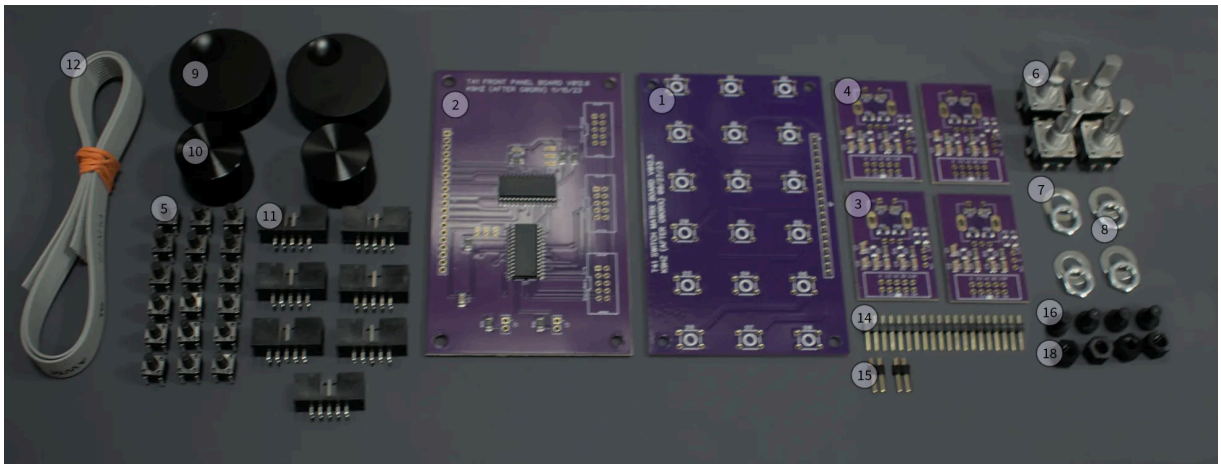
T41-EP SDT v12 Front Panel Assembly Manual



The T41 V12 front panel enables user input to the radio via 18 push button switches and four rotary encoders (with builtin switches). Rotation of the four encoders and 14 of the push buttons are used by the current version of the software. The remaining 4 buttons and the switches built into the encoders are available for customization or future upgrades. Two LED outputs are also available for customization or future upgrades.

A pair of MCP23017 I/O Expander ICs connect these inputs and outputs to the Teensy microcontroller on the main board of the T41 via I2C on a 10-conductor ribbon cable. Power to the front panel is also provided over the ribbon cable.

This manual covers the assembly of my T41-EP SDT v12 Front Panel Kit. If you're building your front panel from another kit or from parts you sourced yourself most of this manual still applies but SMD assembly is not covered.

What's Included (Parts List)

1. (1) Switch Matrix Board
2. (1) Electronics Board
3. (2) Primary Encoder Boards
4. (2) Secondary Encoder Boards

5. (18) Tactile Switches
6. (4) 24 PPR Switched Encoders
7. (4) Encoder Washers
8. (4) Encoder Nuts
9. (2) Large (32mm) Encoder Caps
10. (2) Small (21mm) Encoder Caps
11. (7) 2×5 IDC Box Headers
12. (1) 60cm 10-conductor Ribbon Cable
13. (6) IDC Ribbon Cable Connectors (not pictured)
14. (1) 20pin 2.54mm Header
15. (2) 2pin 2.54mm Headers
16. (4) M3 Nylon Screws
17. (4) M3 Nylon Standoffs (not pictured)
18. (4) M3 Nylon Nuts

Missing a part? Send an email to justin@ai6ym.radio.

You Will Need

1. Soldering Station, hot air or separate heat gun optional but recommended.
2. Multimeter
3. PCB Vice or Helping Hands
4. Jewelers Loupe
5. Solder of your preference, 60/40 tin/lead is recommended.
6. Flux Paste
7. Polyimide (Kapton) Tape
8. Solder Wick

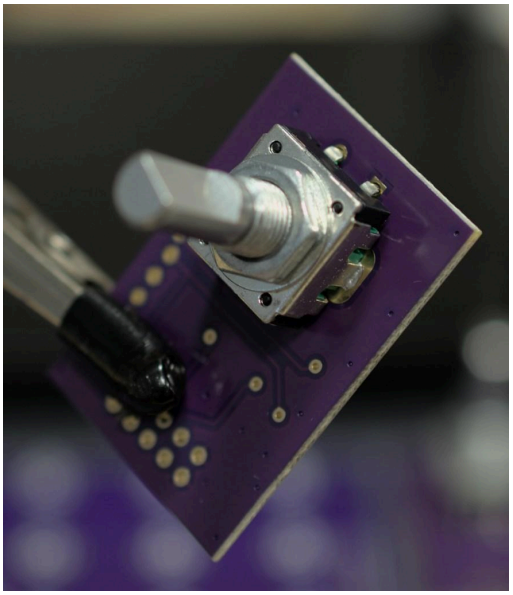
Safety Matters!

Soldering irons are hot. Everything they touch gets hot. Have a fire extinguisher nearby!

Solder splatters. Your eyes are not easily replaceable.

Wear your PPE!

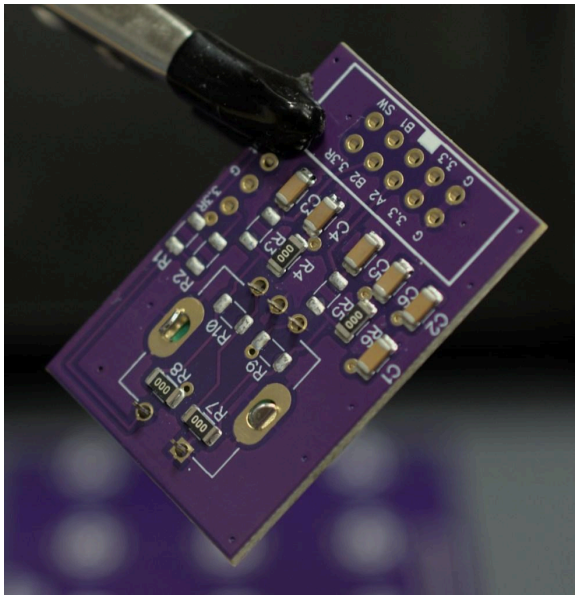
Assembling the Encoder Boards

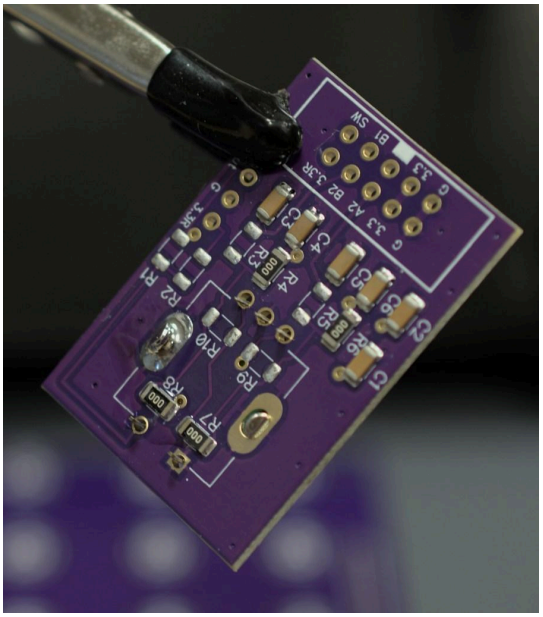


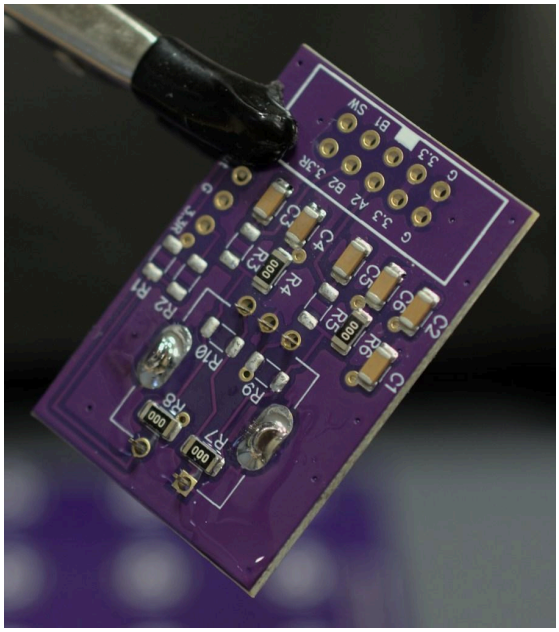
You should have four encoder boards, two pairs of each configuration. The differences between the two pairs will be important later.

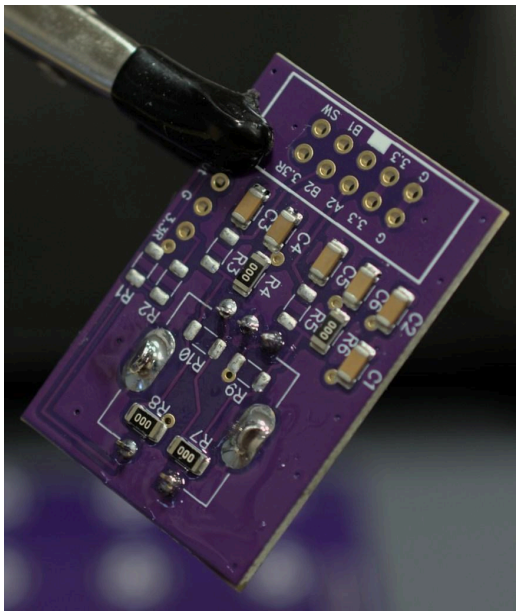
Each board gets an encoder mounted on the back (the opposite side as the passive SMD components already on the board). The large pins on either side of the encoder provide mechanical support. Press these pins in while pushing the encoder onto the board until it snaps in and sits flat on the board.

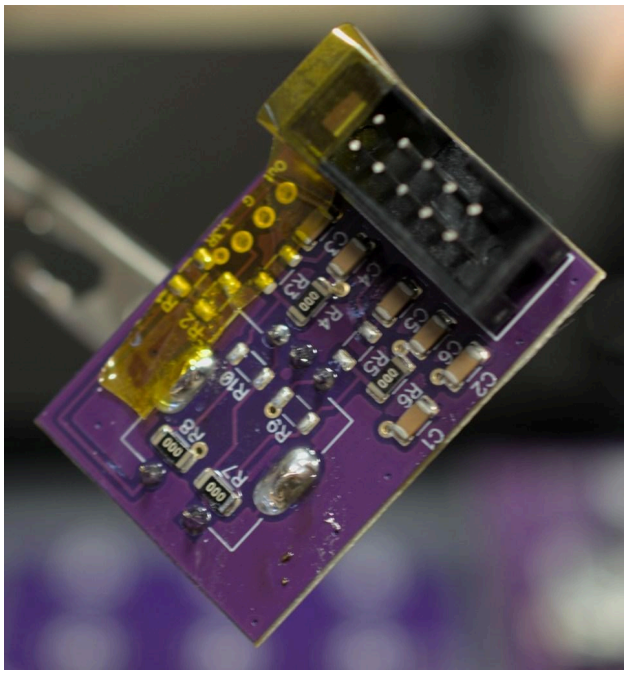
Solder one of the large pins first, preheating with hot air is helpful but not required. After the first pin is soldered check that the encoder is sitting flat on the board before soldering the opposite pin. Double check the alignment before soldering the remaining pins.





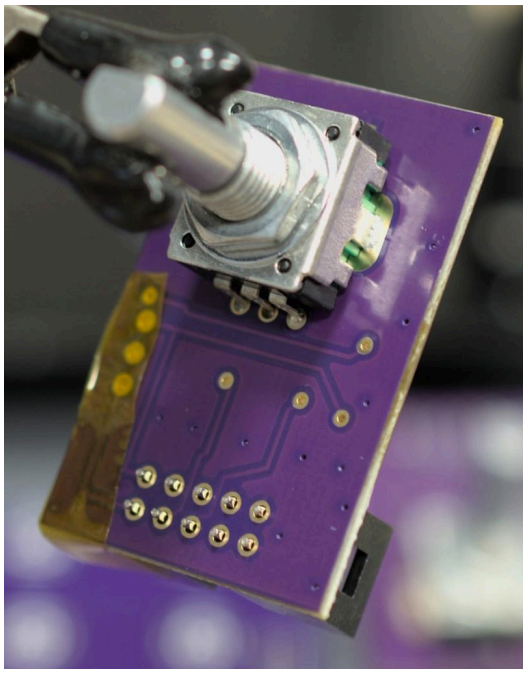


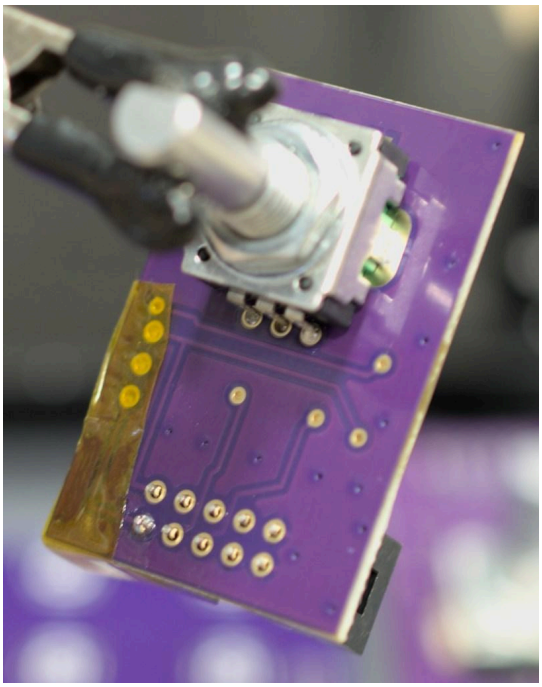


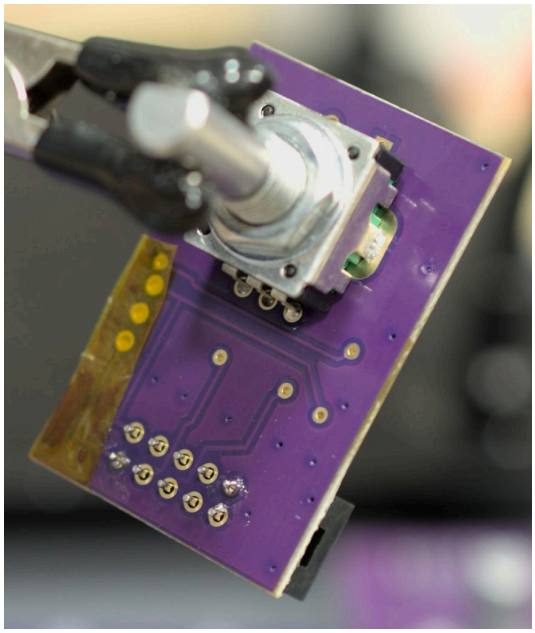


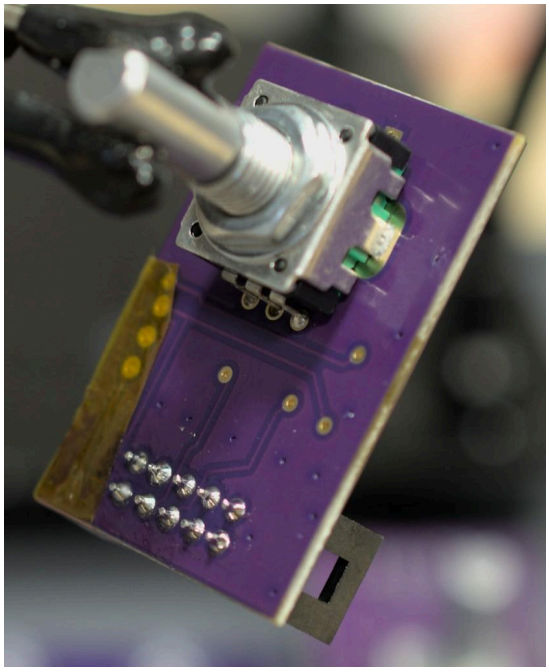
On the front side, place an IDC box header with the key (the gap in the plastic box) on the outside edge of the board. Secure the header temporarily with polyimide tape. On the back side, solder one pin and then check the alignment of the header. Solder a second pin on the opposite side and check alignment again. Once you're sure the header is aligned correctly, finish soldering the pins.

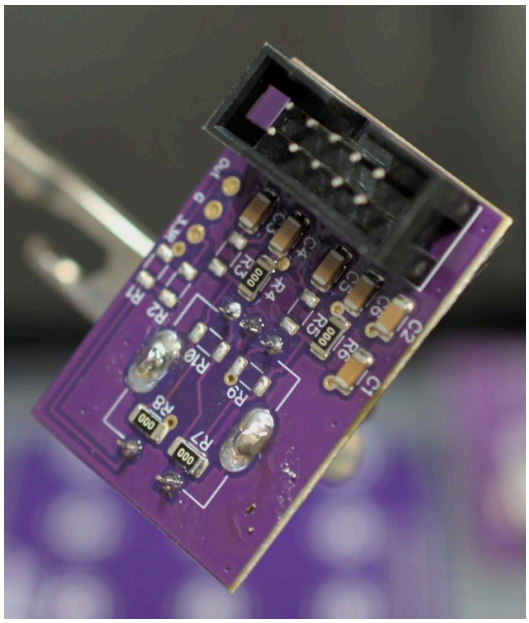
Pro Tip: It's trivial to fix alignment problems with one pin soldered. It's not too difficult with two pins. With three or more pins soldered it's very difficult to fix any alignment issues. Use flux and hot air whenever a pin gives you trouble!







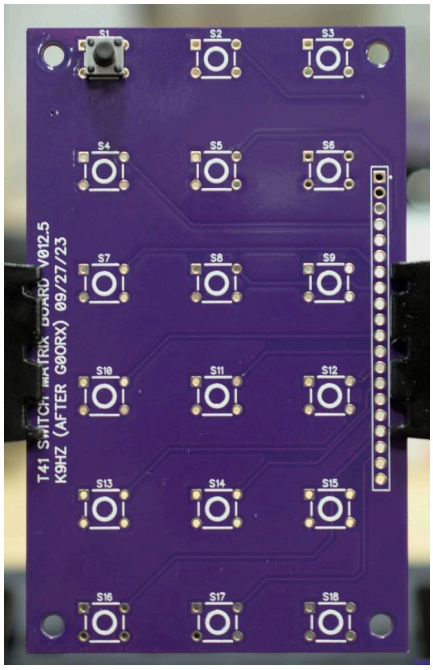




That’s it for the encoder board. Repeat these steps for each of the remaining three boards.

Your encoders come with a washer and nut, which is used to secure the encoders to a case or enclosure later. It’s a good idea to thread those on to the encoder shafts now for safe keeping.

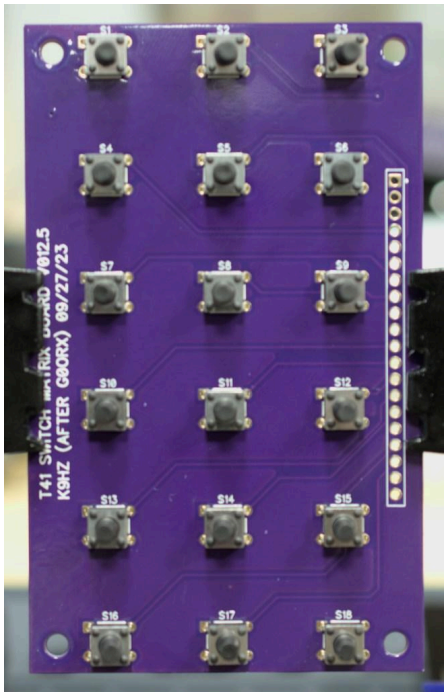
Assembling the Switch Matrix

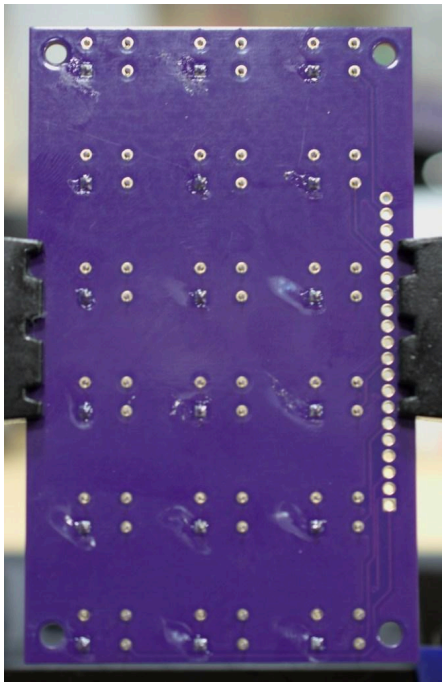


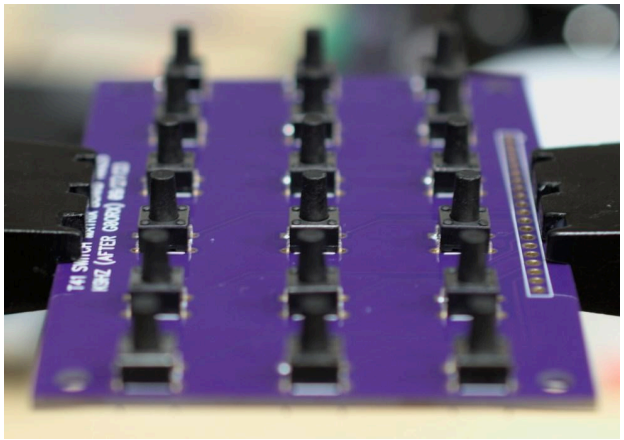
The switch matrix board is simple as the switches are all the same and can only be inserted in one orientation. Snap in each switch to its place on the PCB on the front side by making sure each switch sits on the square outline in the silkscreen. Pay close attention that the switches sit in neat rows.

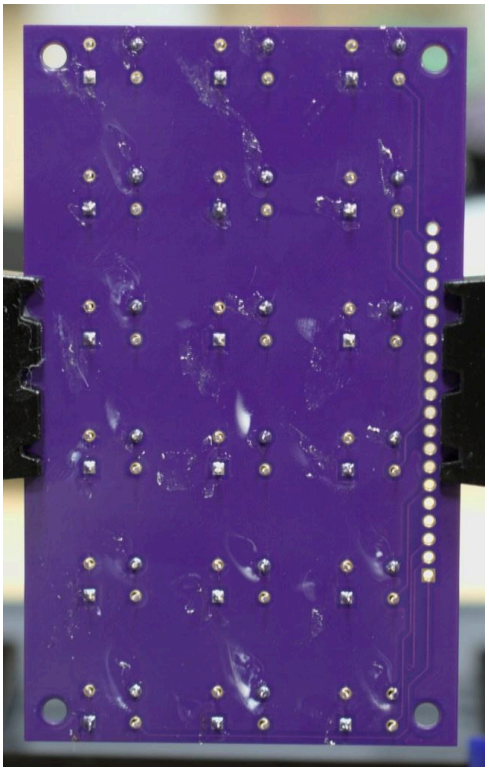
Next, pick and solder only one pin for each of the switches This is to ensure good alignment of the switches before completing this process. It’s easy for the switches to be slightly crooked on the board which can be very noticeable in the final build (so take your time!). With one pin soldered you can easily heat the pin, manually adjust the switch, and remove the iron to secure the switch once in the correct position.

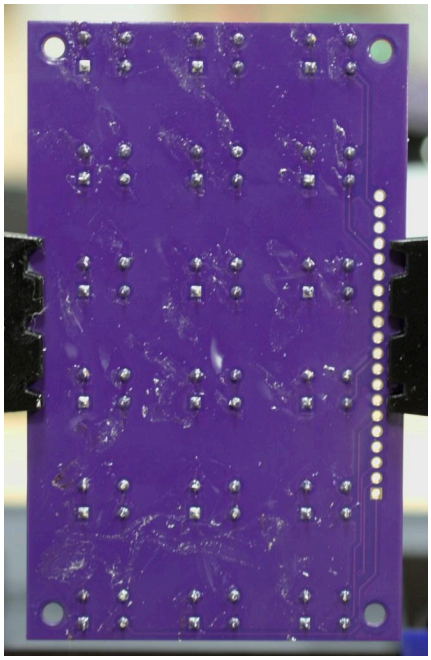
Once you’re sure all the switches are lined up to your satisfaction proceed with soldering the remaining pins of each switch.

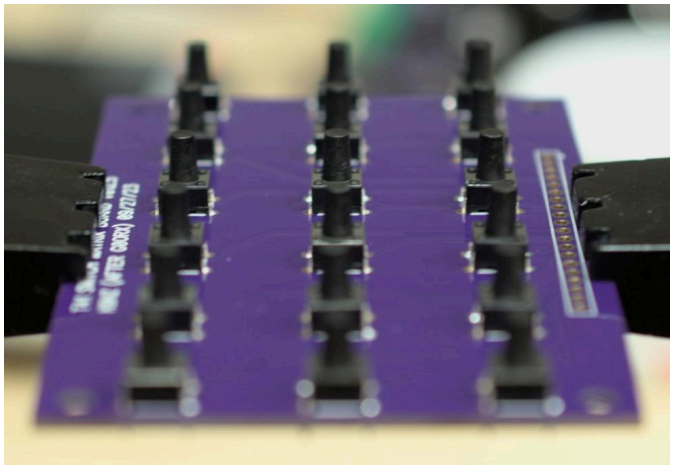

S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18









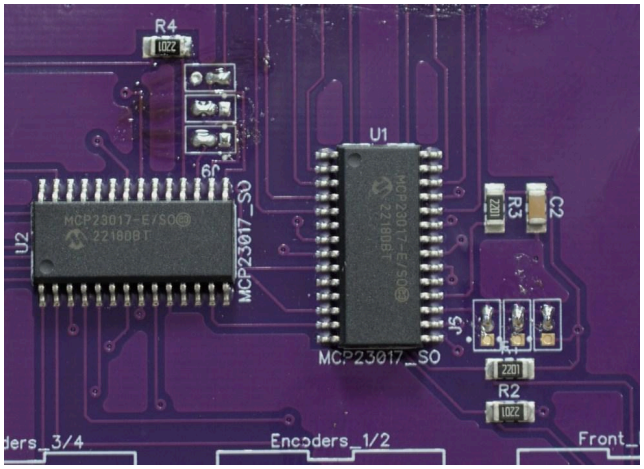


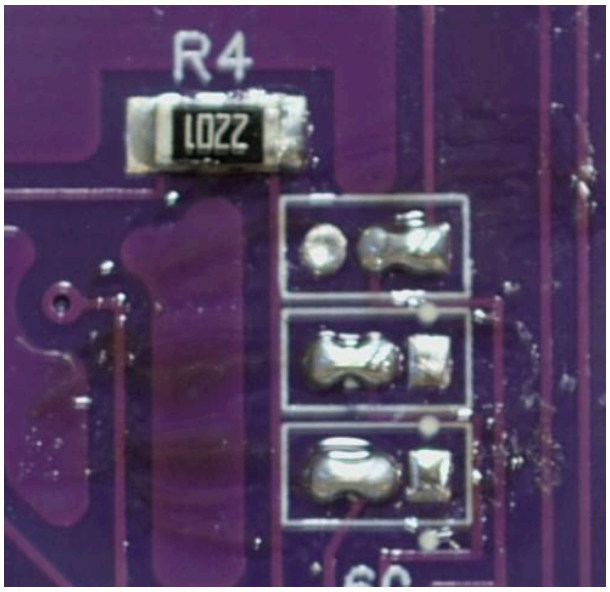
Set the Switch Matrix board aside, that's all there is to do for now.

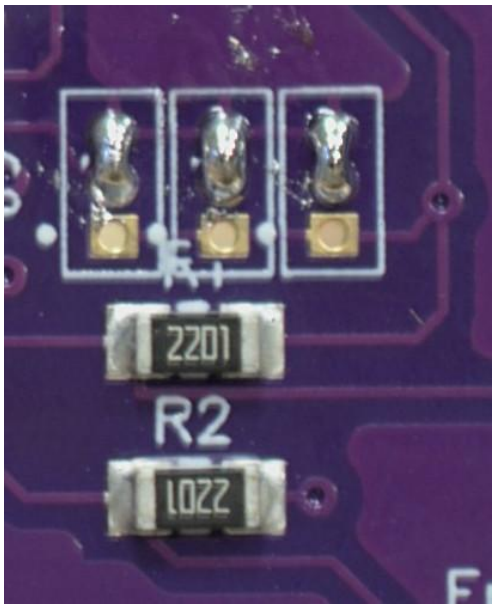
Assembling the Electronics Board

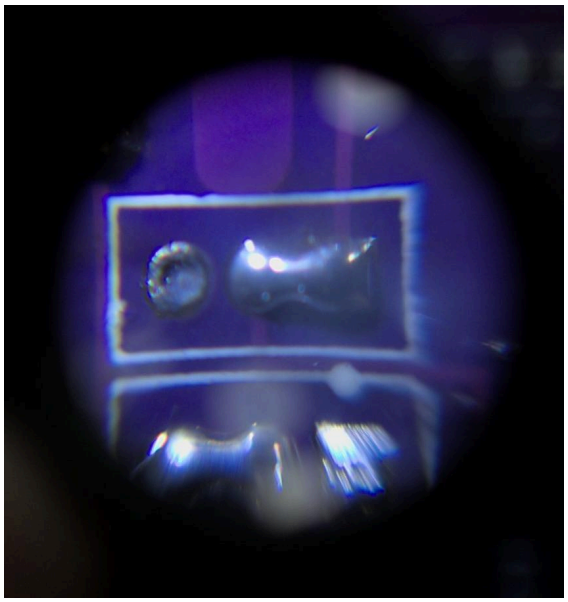
The two IO expanders on the Electronics Board must each be set to the correct I2C address by creating solder bridges on the address selection pins. These pins are quite small, so this is a little challenging. The correct addressing is shown below.

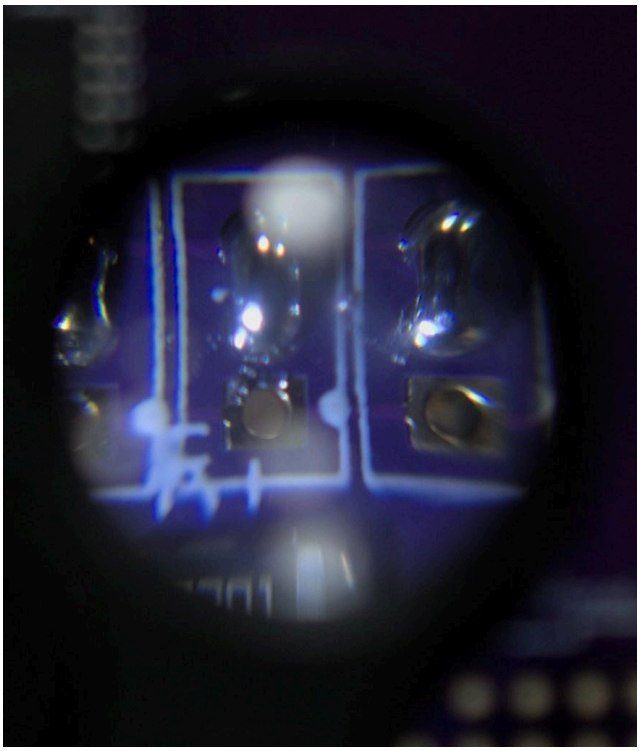
Once the solder bridges are created, inspect each one with a jewelers loupe. It's quite easy to accidentally bridge all three pins which will short *Vcc* (3.3V) to *Gnd*. It's also possible to form a cold joint that pulls away from one of the pads and so does not make contact even though a visual inspection appears to show a solid joint. Follow the traces on the board (or review the schematic) and check continuity on the address pins to confirm. **Pro-Tip: A bit of spare wire, around 28AWG, or a cut off from a through hole component lead can be used to span the two pins. This method is a bit easier to modify in the future.**


R4
1022
U1
U2
MCP23017-E/SO
2218DBT
MCP23017_SO
R3
2201
C2
J5
R2
Encoders_1/2
Front_

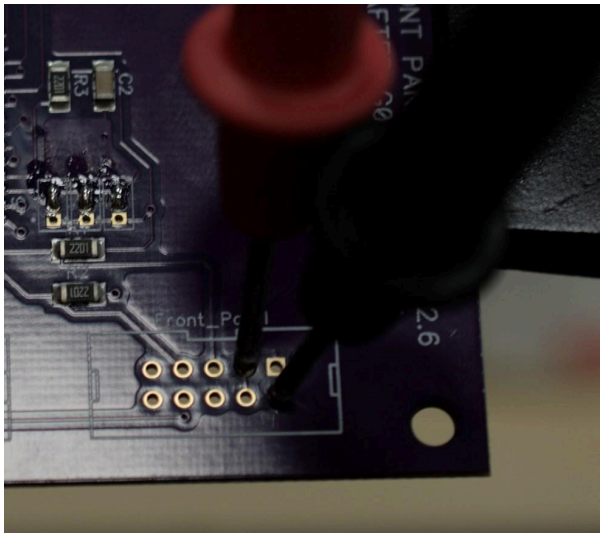

R4
1022


2201
R2
1022

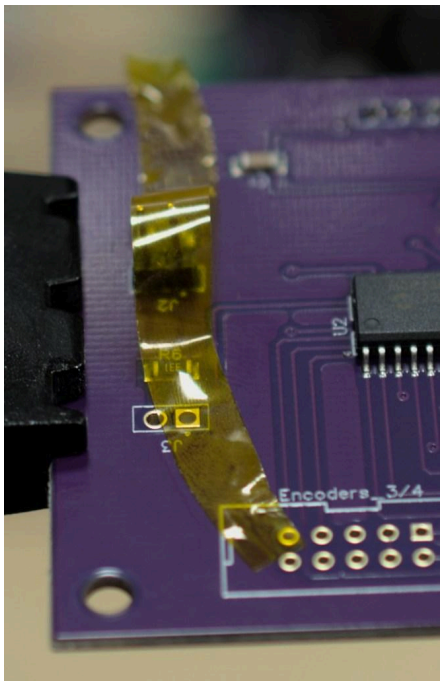


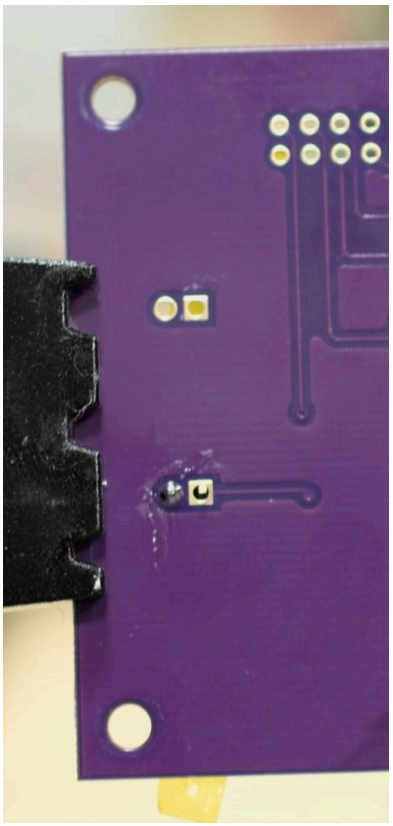


Pro Tip: Check for continuity between *Vcc* and *Gnd* on the *Front_Panel* connector to double check your work. *Vcc* is the 5th column on the connector, *Gnd* is the 4th column.

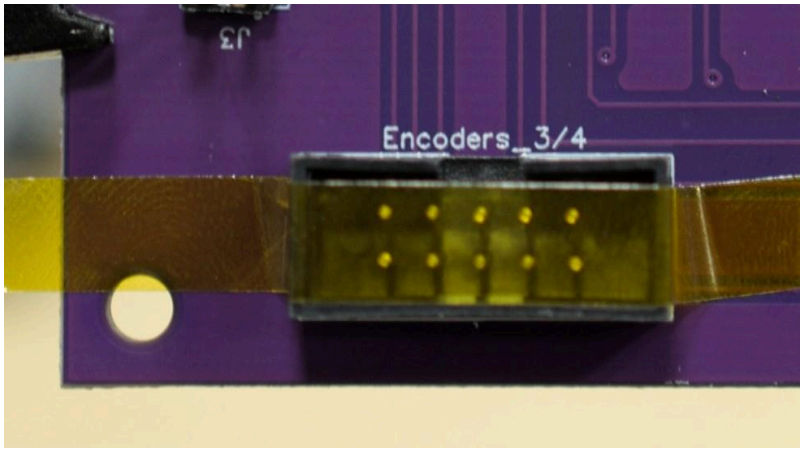


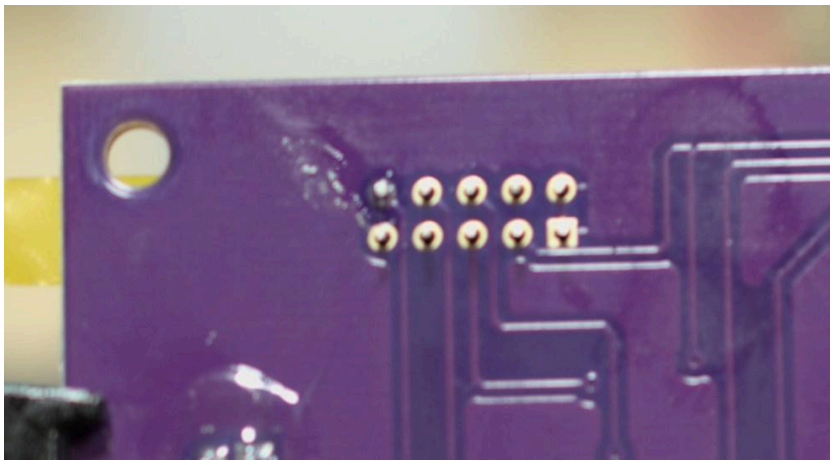
This board has two headers, *J2* and *J3*, for optional LEDs. These headers should face out from the front of the board. Place one header and secure it with tape. Solder a single pin from the back of the board and check / fix alignment of the header before soldering the second pin. Repeat for the second header.

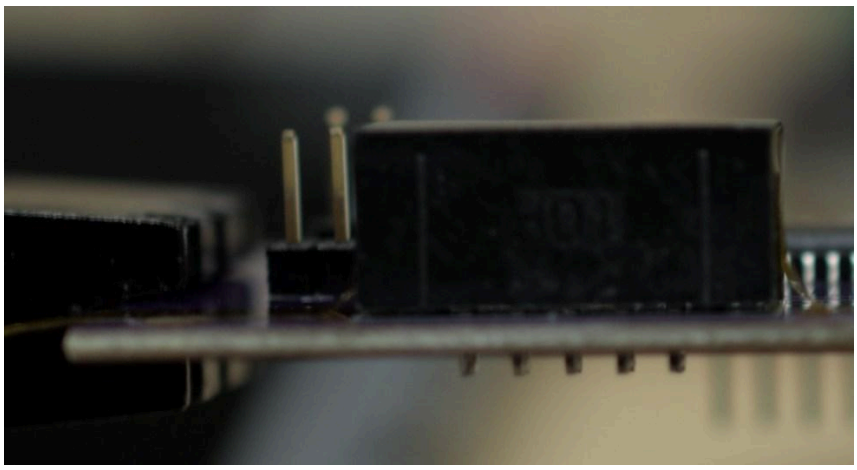


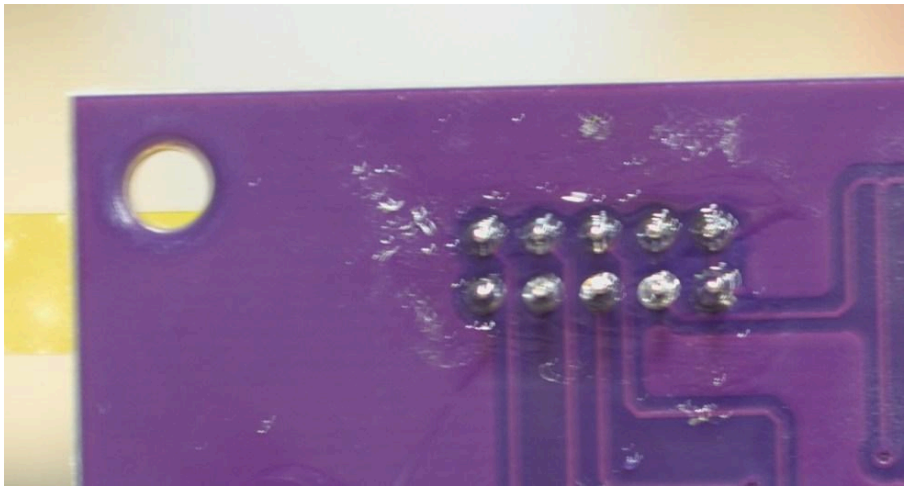


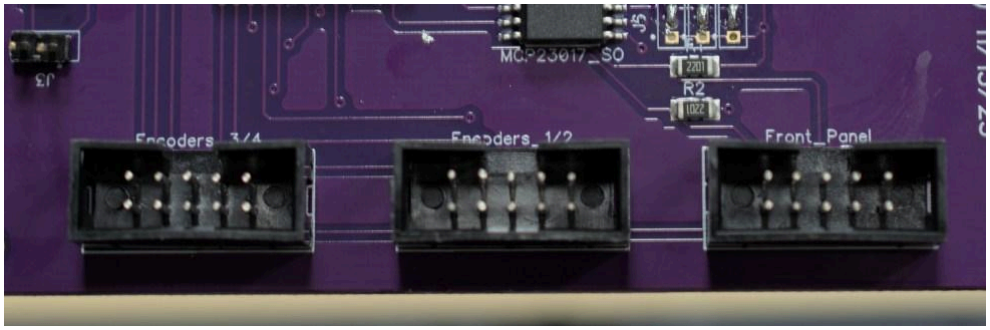
Place the first JDC box header on the front of the board and secure it with tape. Solder one pin on the back, check the alignment of the header, then solder the pin on the opposite side, and check alignment again. When you're sure the header is sitting flat on the board and aligned to your satisfaction, solder the remaining pins. Use heat and flux on any difficult pins. Repeat for the remaining two headers.


J3
Encoders_3/4



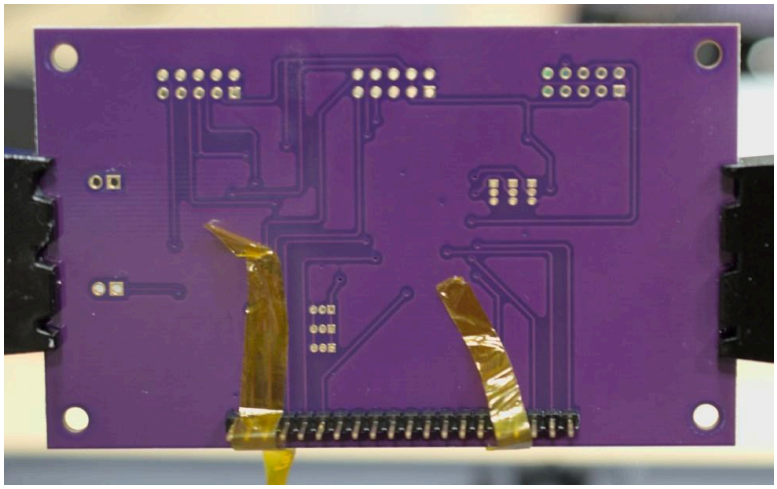


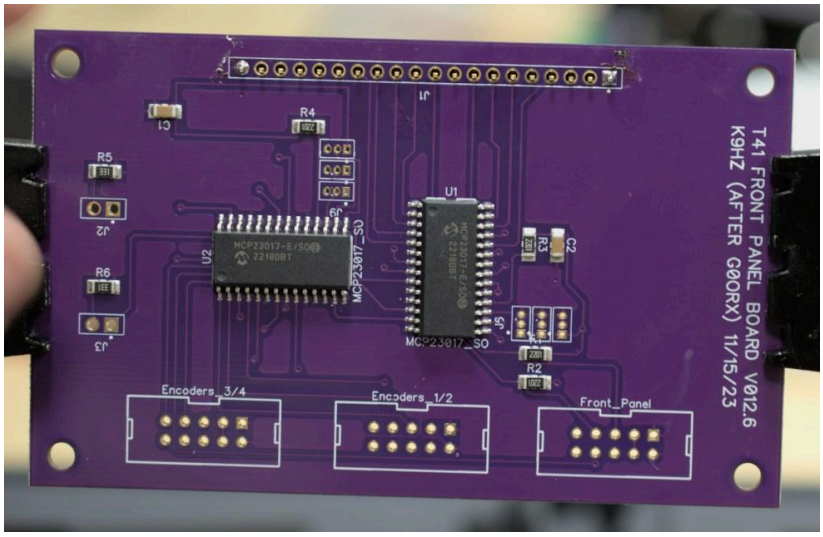


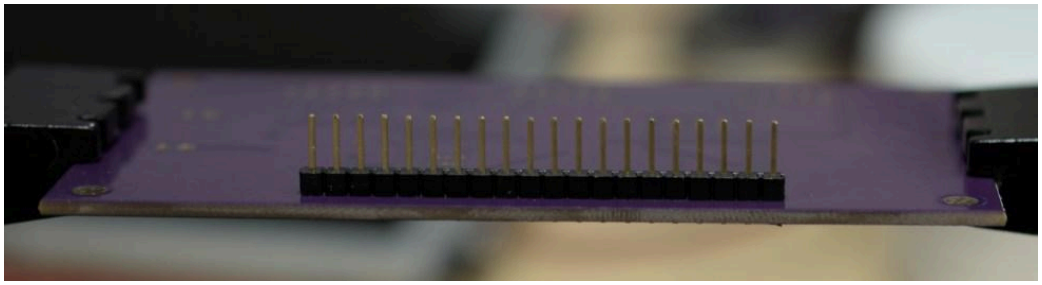


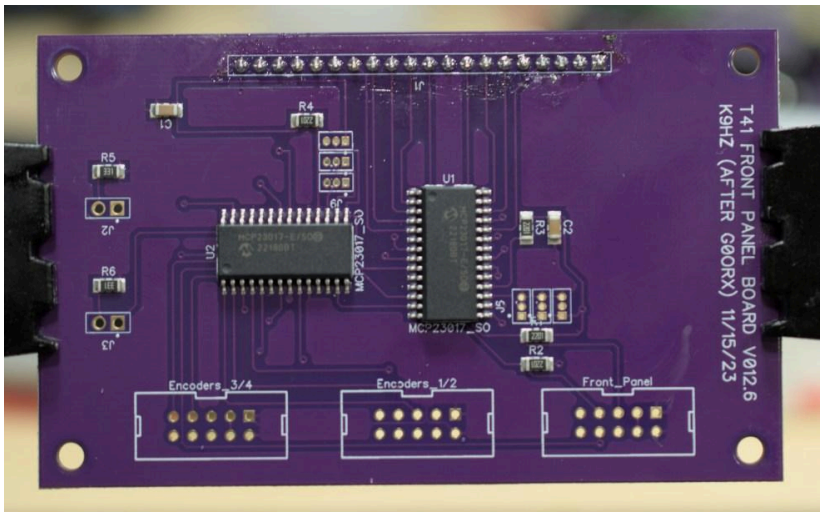
Finally, place the 20pin header which connects the electronics board to the switch matrix board. This header is installed with the pins on the back. Start by soldering one pin, check alignment, solder a second pin on the opposite corner, check alignment again, and solder the remaining pins only when satisfied with the position of the header.

Note: These images show the board without components installed in previous steps. The order parts are installed in this manual is much more convenient than the order in which I installed parts.







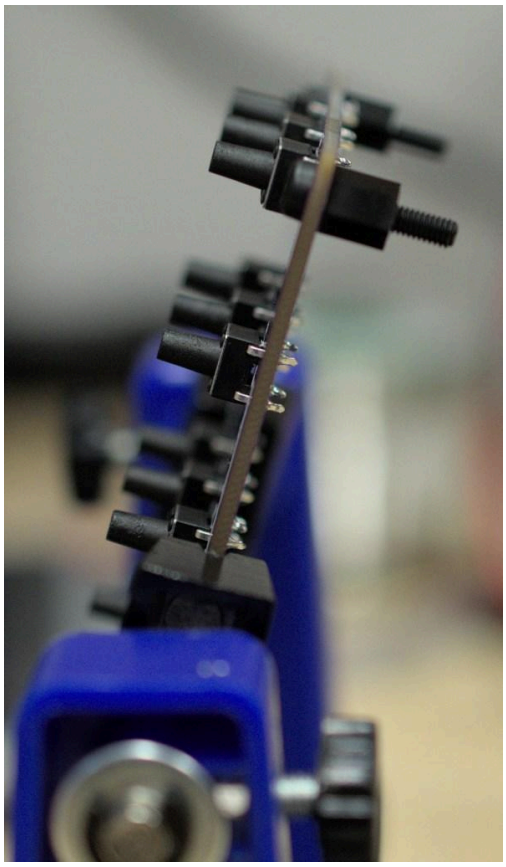


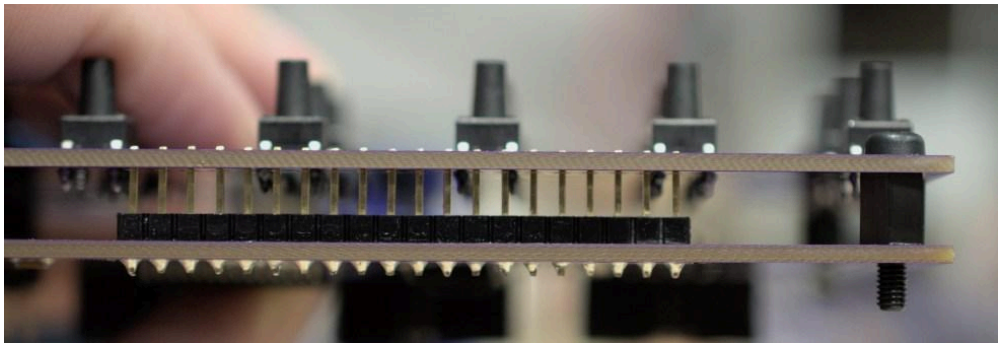
Connecting the Electronics & Switch Matrix Boards

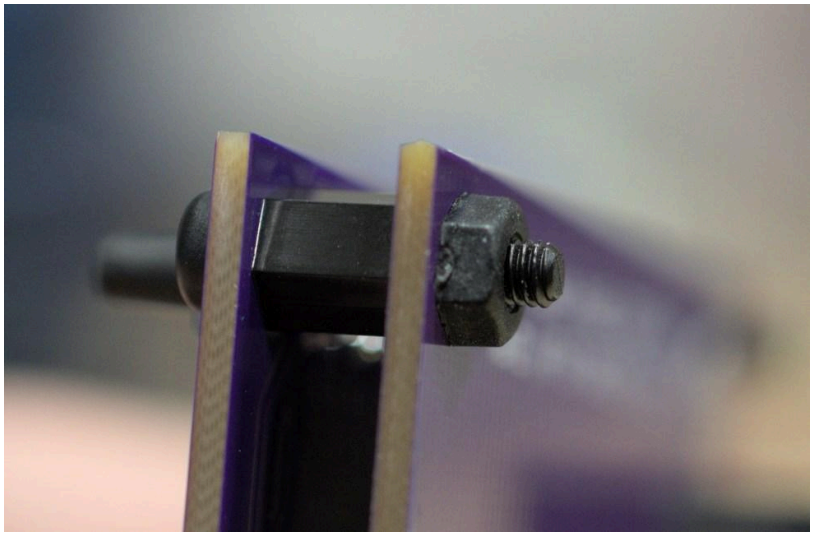
Pro Tip: If your boards are covered in flux and other debris from soldering now is a good time to clean them. It will be much more difficult once the boards are attached to each other.

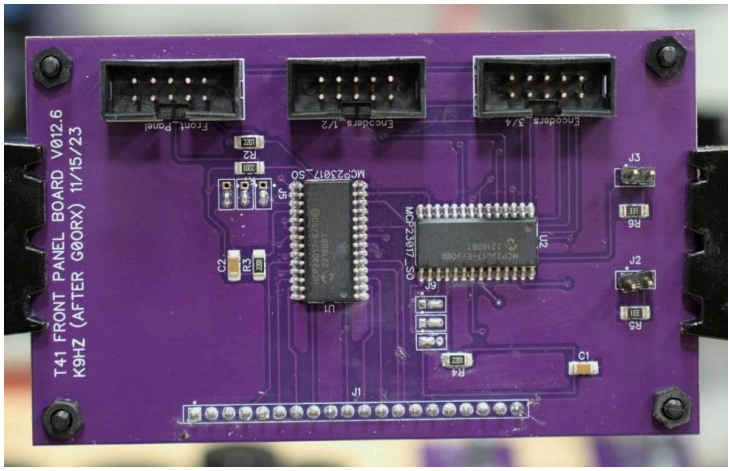
These two boards are mounted to each other using nylon screws, standoffs, and the nuts included in the kit. First place a screw through the front of the switch matrix board and thread on a standoff on the back side. Finger-tight is enough. Repeat for all four corners.

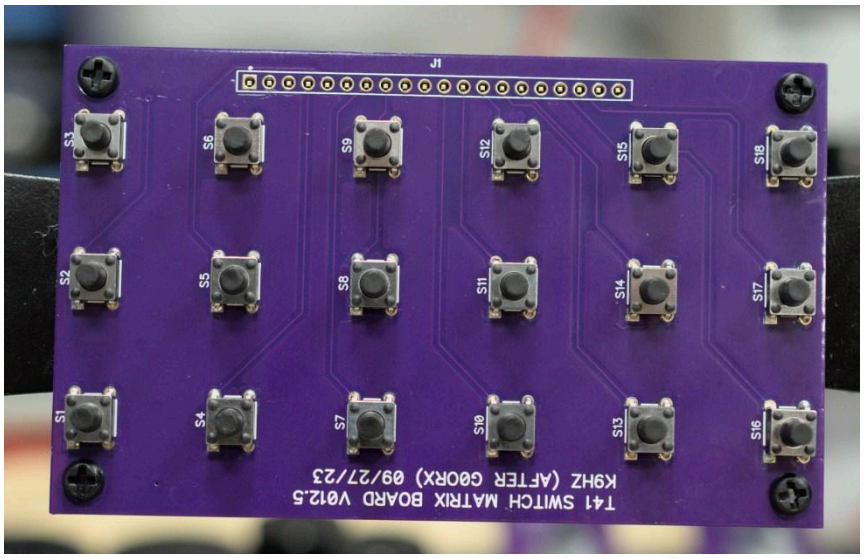
Next, align the electronics board. The 20pin header will fit through the switch matrix board and the IDC connectors will be accessible on the back of the assembled boards. Use the nylon nuts to secure the electronics board on each corner.



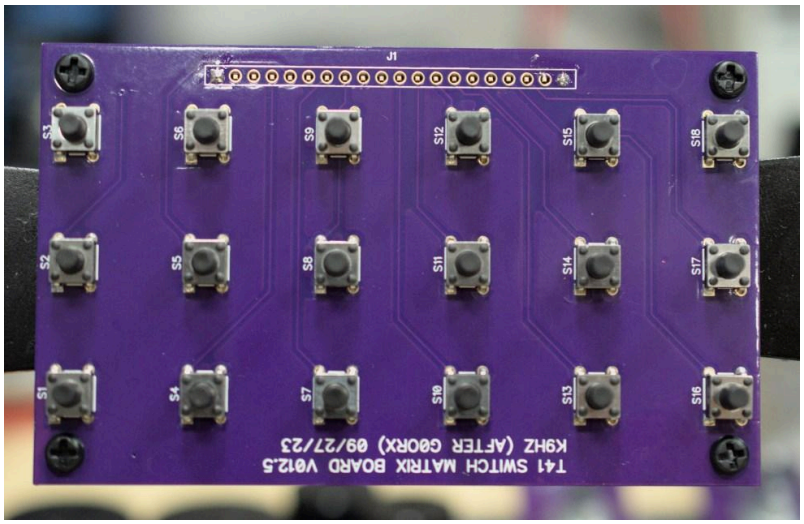


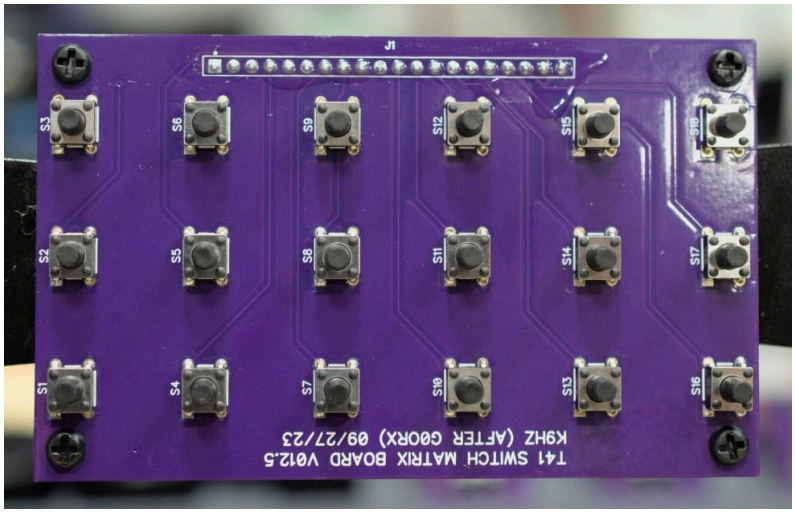


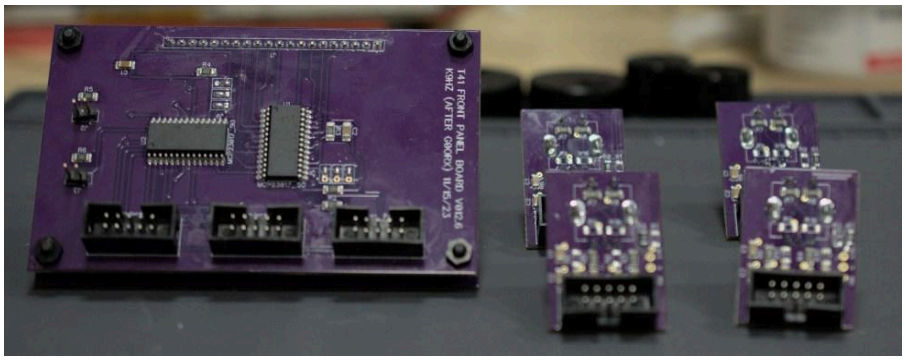




Finally solder the header connection on the switch matrix board. Start with one pin, check alignment, solder a second pin on the opposite side of the header, check alignment again, and finish soldering the header.







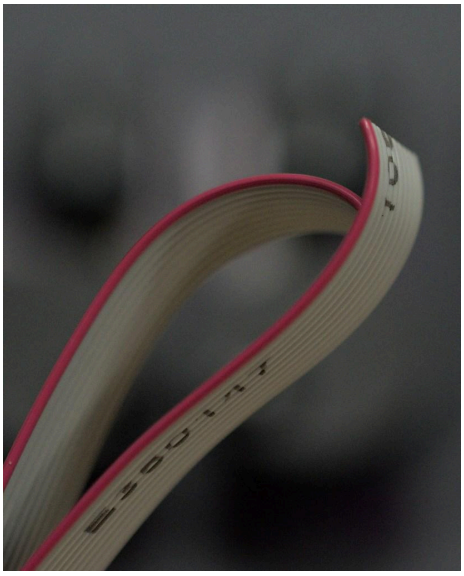
Connecting the Encoder Boards

The Encoder Boards are attached on two ribbon cables to the electronics board. One IDC header on the electronics board is labeled *Encoders 1/2* and the other is labeled *Encoders 3/4*. Now is when the difference between the two sets of encoder boards is important.

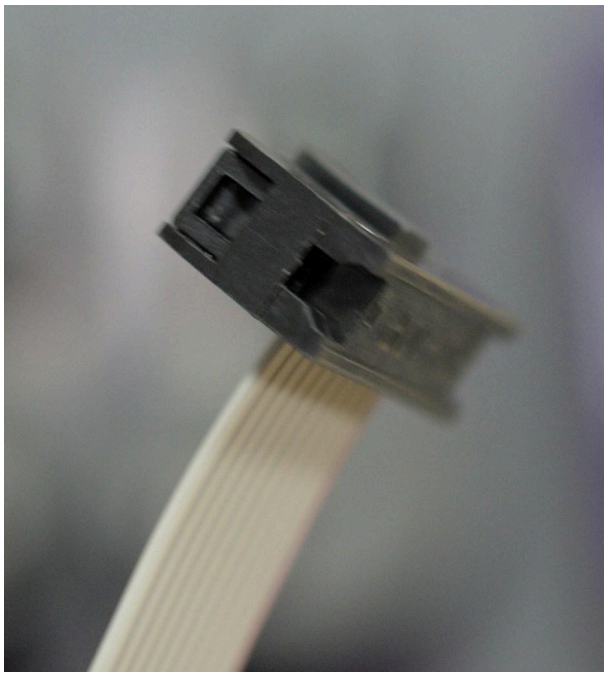
Encoder 1 is the Volume encoder, Encoder 4 is the Center Tune Encoder. These two boards will have R1, R4, and R6 populated.

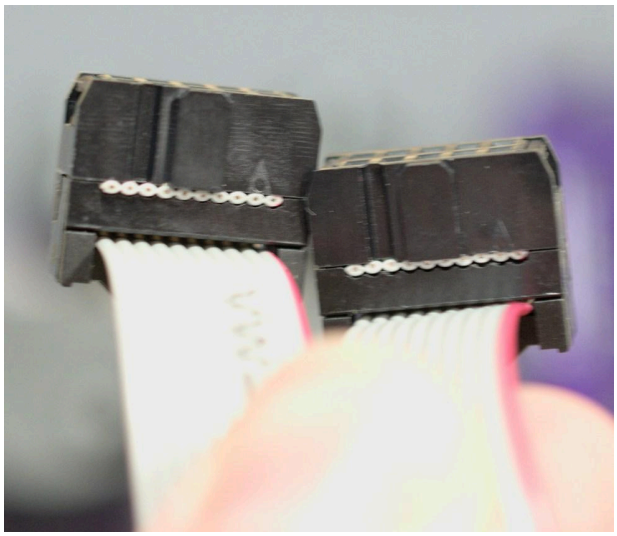
Encoder 2 is the Filter Encoder, Encoder 3 is the Fine Tune Encoder. These two boards will have R2, R3, and R5 populated.

To connect the encoders to the electronics board first you will need to make two ribbon cables, each with three connectors, one on each end and another in the middle of the cable. Cut the included ribbon cable into two pieces (each about 30cm / 6” long). If desired, the cabling can be



shorter, but shorter can be more difficult to work with.





Separate a ribbon connector enough to slide the ribbon cable through. Align the red line on the cable with the triangle marker on the connector. These markings indicate pin1 and ensure the cable is oriented correctly. Pay attention to the position of the key bump on the connector and the path the cable will follow once folded over the top and secured. If the orientation isn't what you would like for your build, remove the ribbon cable, flip it over, and slide it back into the connector.

Once you like the orientation of the cable crimp on the connector by squeezing the back of the connector and the front together. Fold the ribbon cable over the top of the connector and clip on the strain relief. Repeat this process for the connector at the opposite end of the cable.

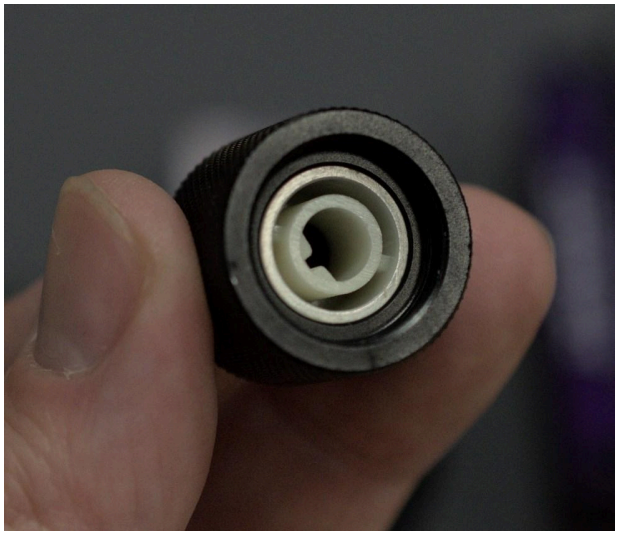
Pro Tip: Use a bench vice or rubber hammer to gently and evenly press the two parts together.

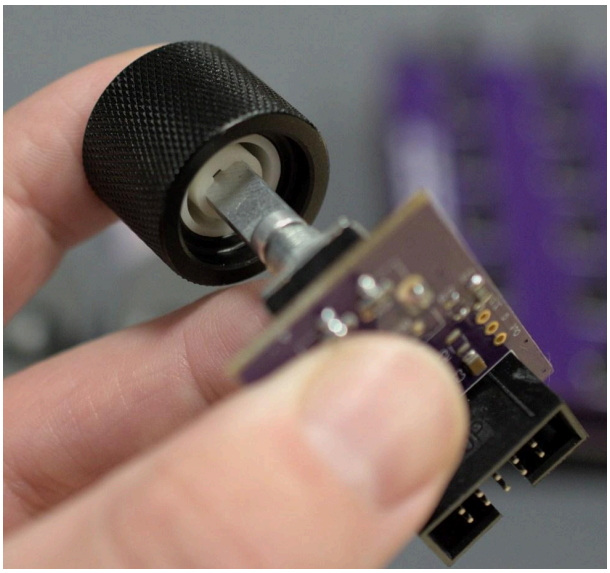
Connect encoders 1 & 2 on the ribbon cable and connect this cable to the electronics board *Encoder 1/2* header. Repeat for the cable building and connection steps for encoders 3 & 4. The order of encoder boards on the ribbon cable does not matter.

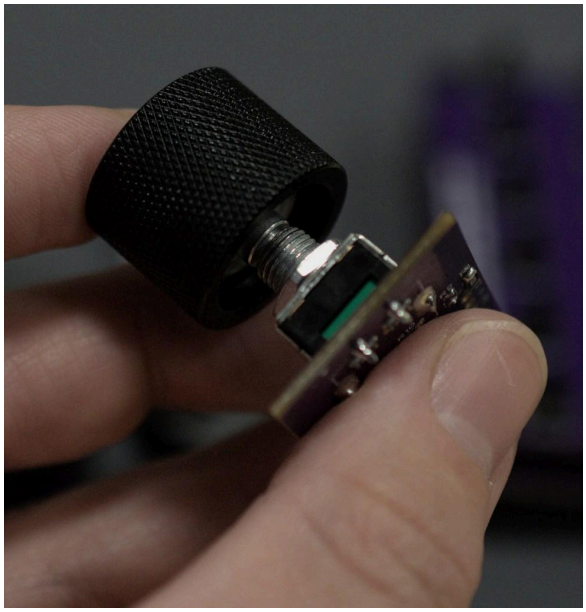
Mounting the Encoder Knobs

Pro Tip: Only start this section after mounting the encoders in a case. The nut that holds the encoder and board onto the case will sit under the knob.

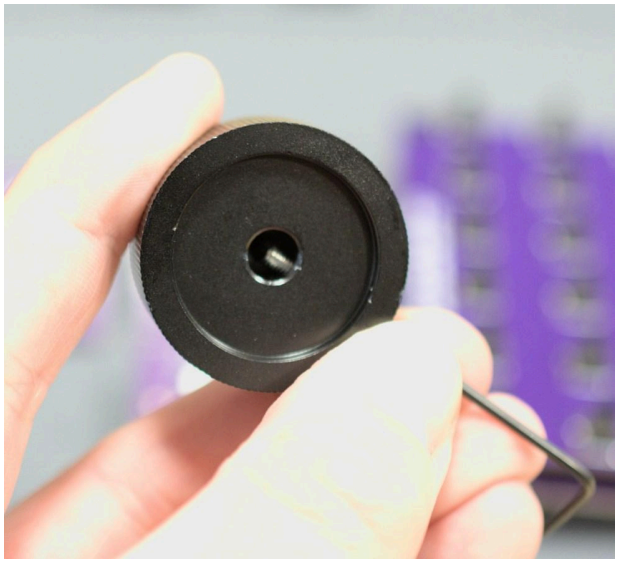
The small encoder knobs (for the Volume and Filter encoders) are press-fit. Just align the encoder shaft with the back of the knob and press firmly until the parts snap together.

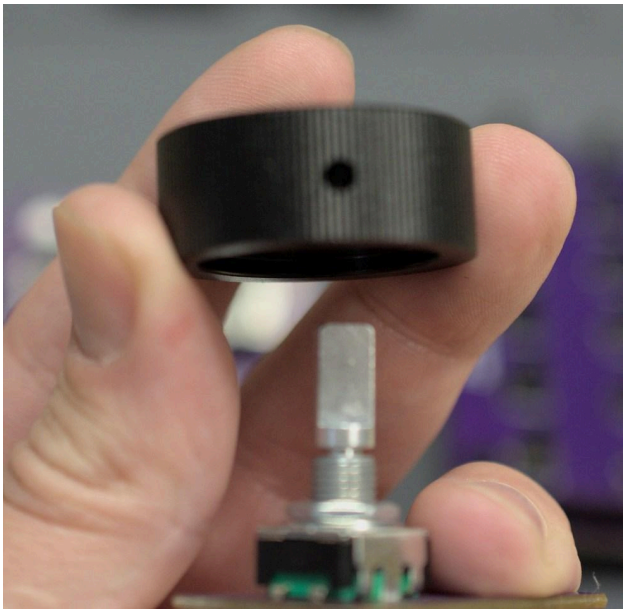


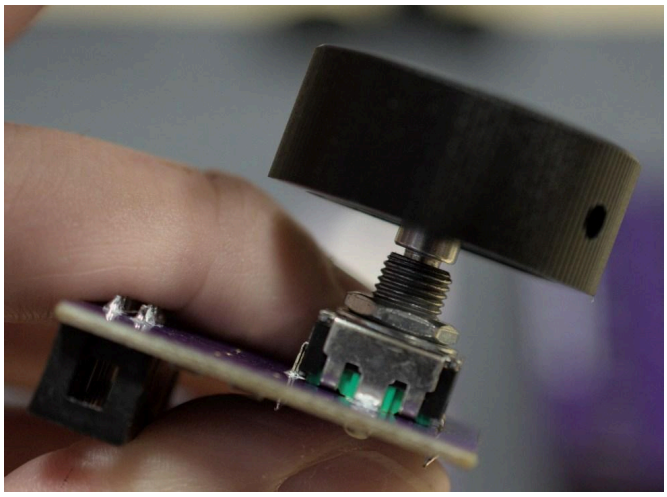




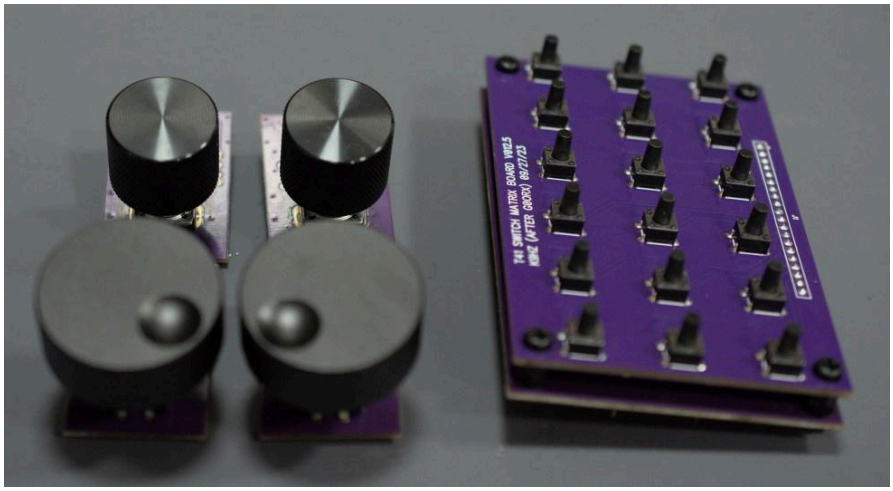
The large encoder knobs are secured by a small screw. Use a 1.5mm hex key to back the screw up in the knob to make room for the encoder shaft. Then slide the knob over the encoder shaft with the screw facing the flat part of the shaft, and tighten the screw until the knob is secure. Do not over tighten.

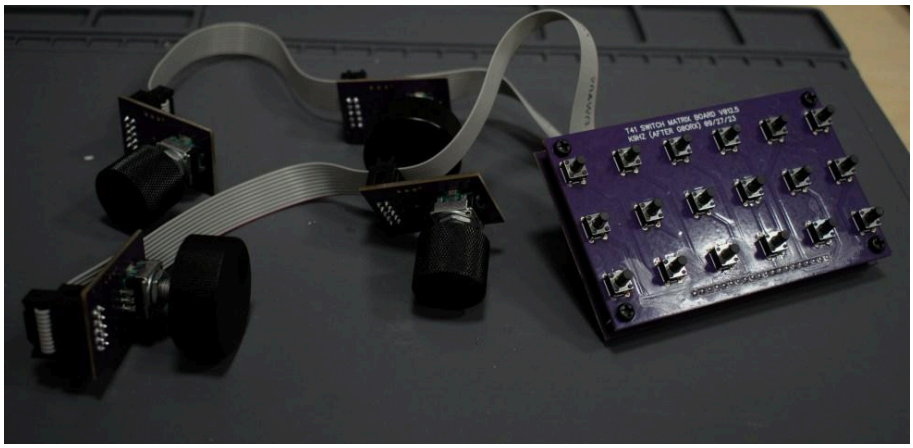






That’s it! Your front panel is ready for use in your radio.





Testing the Front Panel

The front panel is powered through the main board. Connect the electronics board and the main board via a ribbon cable (J5 on the main board is labeled Front Panel). Power up both boards through a current limiting 12V supply to ensure any shorted connections or other problems do not damage the boards. The additional power draw from the front panel is miniscule and the boards should produce no noticeable heat on any component.

If a high power draw is noticed it is likely that one of the address selection pins is shorted. Turn off the power supply and disconnect the boards before troubleshooting. Resistance between the 3.3V lines and ground on the front panel boards should be infinite / unmeasurable (or at least many megaohms, if your meter is sensitive enough).

A sketch for testing the front panel buttons, encoders, and encoder switches is available on my GitHub. If you wish to test the front panel build thoroughly, upload this sketch to your Teensy microcontroller, connect the front panel to the main board (via another ribbon cable, available as part of my interconnect kit), and power up the boards. Monitor the USB serial port on the Teensy for any errors and activity on the front panel. Each button press, encoder rotation, and encoder press will be reported.

Notes:
1) The test software isn't polished, production code. It may lock up and require resetting the Teensy or require buttons to be held-down a moment before reporting a button press.
2) Button presses are zero indexed in the test sketch but one indexed on the board silkscreen. A press on SW1 will be reported as button 0.