Quad Clock Distributor Expander

Kit Builder's Guide for PCB v1.0

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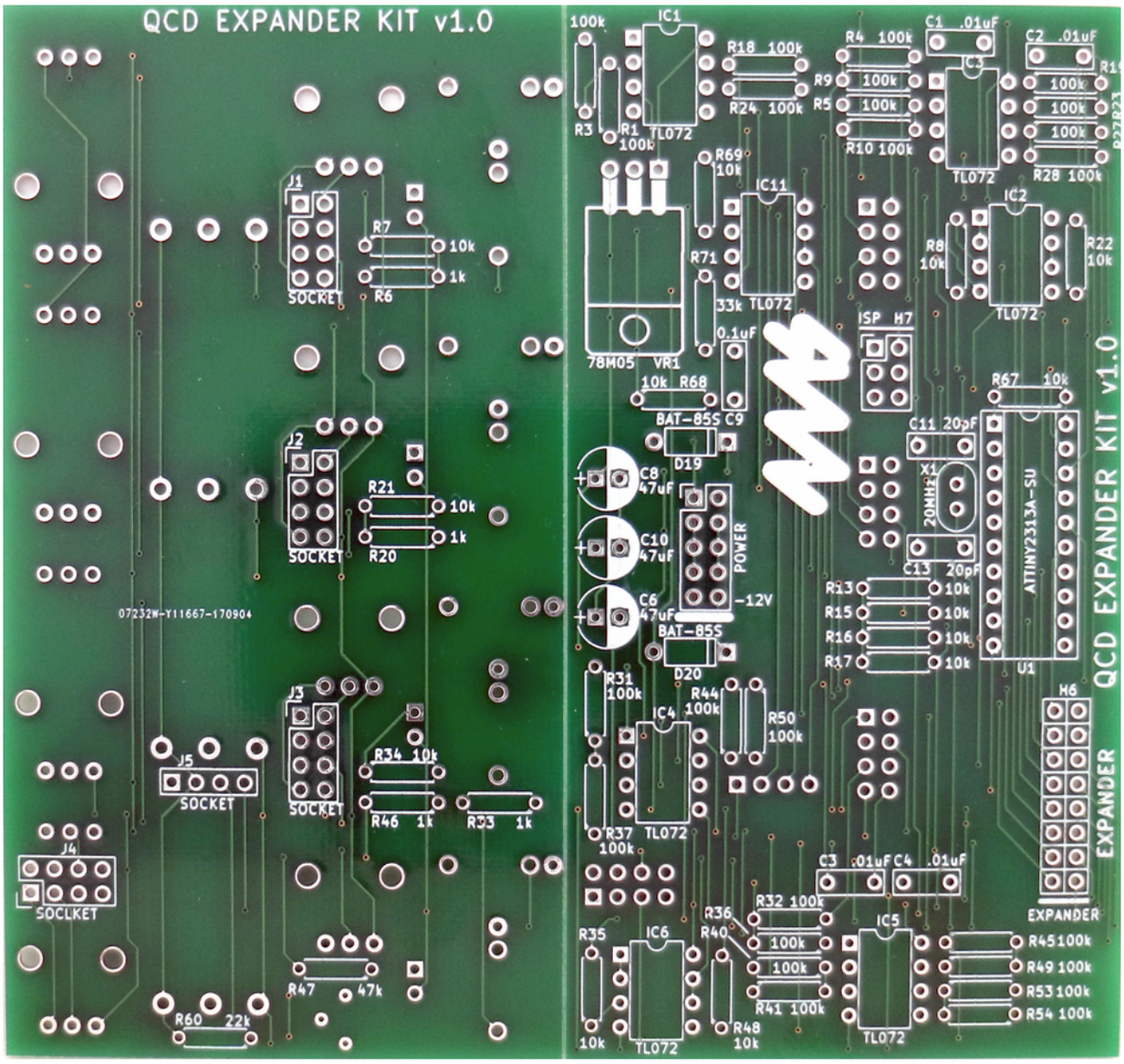


QCD EXPANDER

This guide is for building a Quad Clock Distributor Expander (QCD EXP). It's an intermediate-level kit. You should have basic soldering skills and a basic familiarity with identifying electronics components.
Note: The QCD EXP PCB is actually two PCBs that are V-scored so they can be snapped apart. It's easiest to assemble the board in one piece, and then snap the boards apart afterwards in step 6.

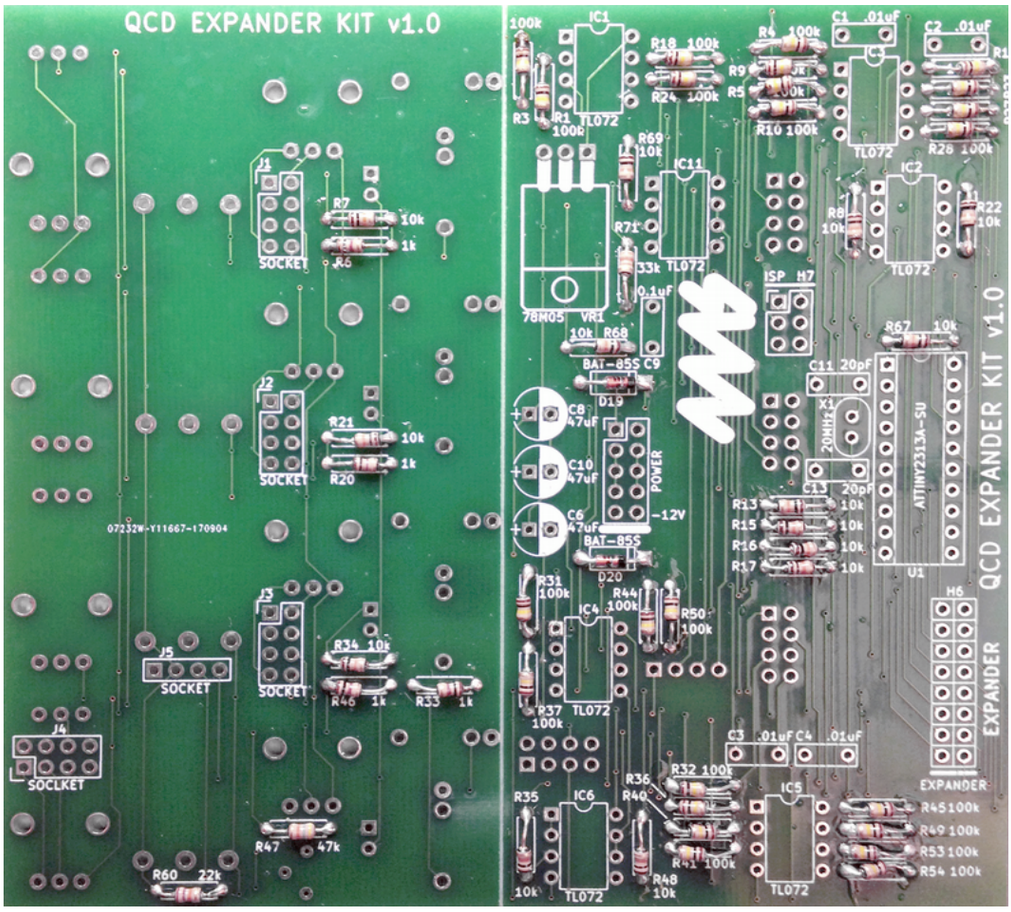
Tools Needed:

- Soldering iron, solder
- Flush snips
- Needlenose pliers (for removing a component if you make a mistake)
- 5/16", 3/8”, and 1/4” socket drivers (optional: pliers will work too if you're careful)
- Multimeter (for reading resistor values if you don't know the resistor color code chart)

Step 1: Resistors & Diodes

Insert and solder the resistors and diodes. There are forty-five 5% resistors (tan body) and two BAT-85S diodes. Due to variations in components, you may find that some resistors are larger than others in your kit. The size is irrelevant, only the color bands matter. The diodes must go in with the black band facing the tip of the arrow. (see photo in step 3 for a more detailed view of this orientation)
After soldering, snip the leads nearly flush to the PCB (you'll be snipping the leads flush on all the components after soldering).

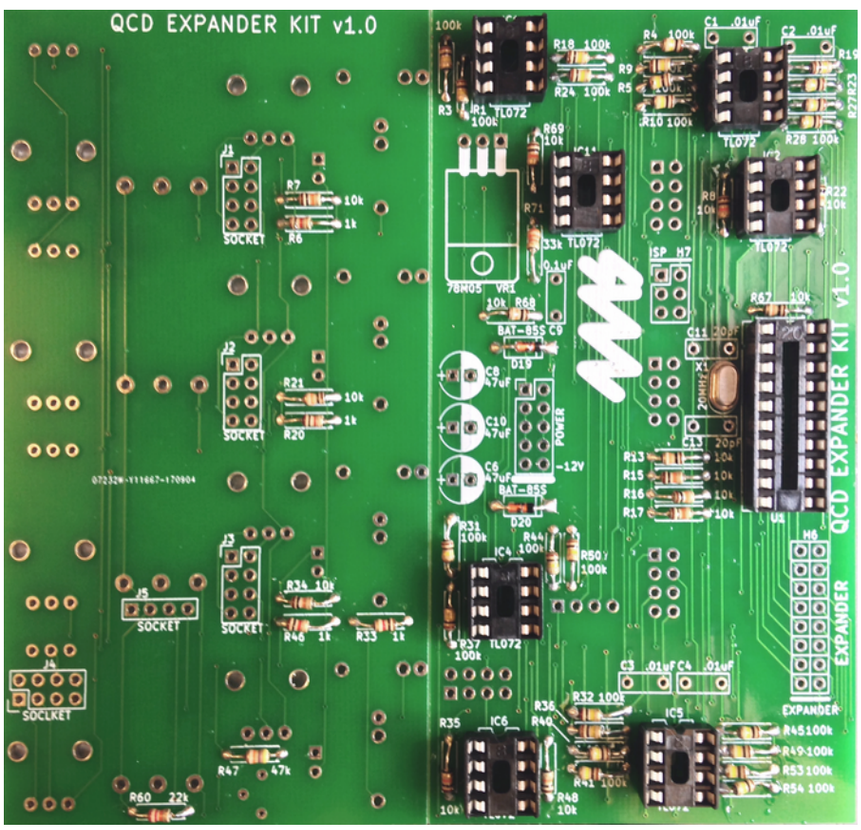
The 45 tan resistors (5%):	The 2 diodes:
• *1k x 4 (brown black red gold)* • *10k x 14 (brown black orange gold)* • *22k x 1 (red red orange gold)* • *33k x 1 (orange orange orange gold)* • *47k x 1 (yellow purple orange gold)* • *100k x 24 (brown black yellow gold)*	• *BAT-85S x 2* ***Note orientation! Band=arrow tip*** *(see pic in Step 3)*



Step 2: Sockets and Crystal

Insert and solder the IC sockets. The notch in the sockets should line up with a matching notch drawn on the PCB. Finally, insert and solder the 20MHz Crystal (orientation does not matter, see detailed pic in Step 3).

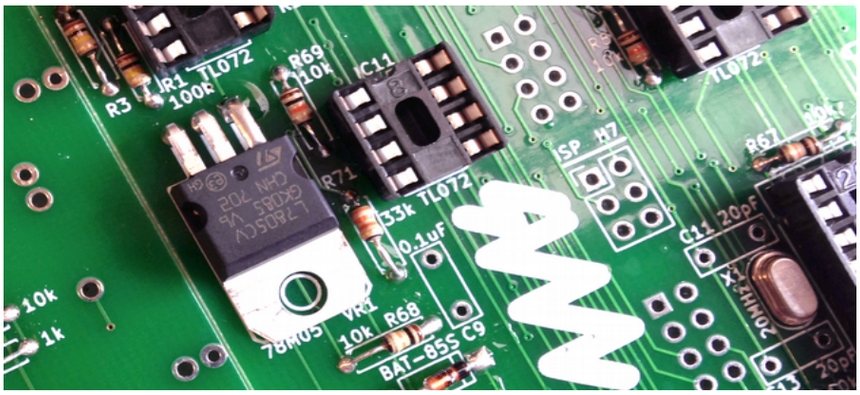
- *8 pin socket x 7*
- *20 pin socket x 1*
- *20MHz Crystal x 1*



Step 3: Voltage Regulator

Next, insert and solder the voltage regulator (7805). Bend it down flush to the PCB (as shown in the photo). The words must be facing upwards.

- *7805 voltage regulator – Bend down flush to PCB x 1*



Above (clockwise): BAT-85S diode (very bottom of image, note band points to the right), 7805 regulator, 20MHz crystal

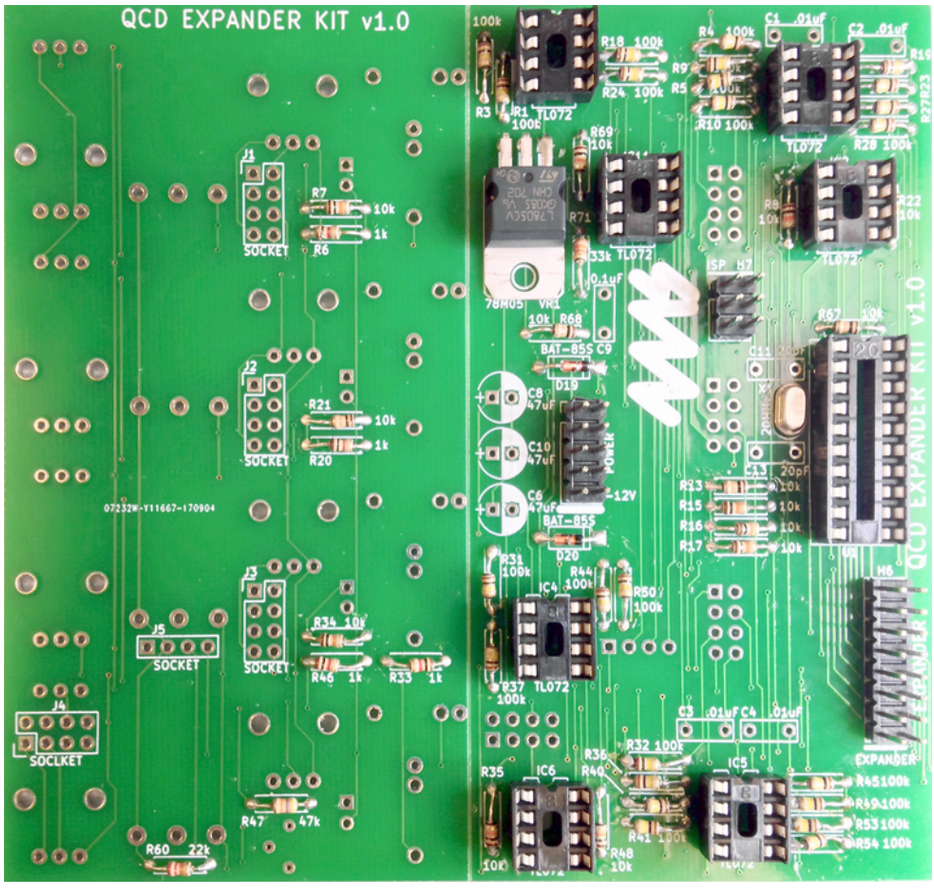
Step 4: Header pins

A. Insert and solder the male header pins on the top board first. Since the headers fall out easily, it helps to put a piece of cardboard or a book over the PCB, then flip over the book and PCB together before soldering.

Peek ahead, don't accidentally put male headers where females go!

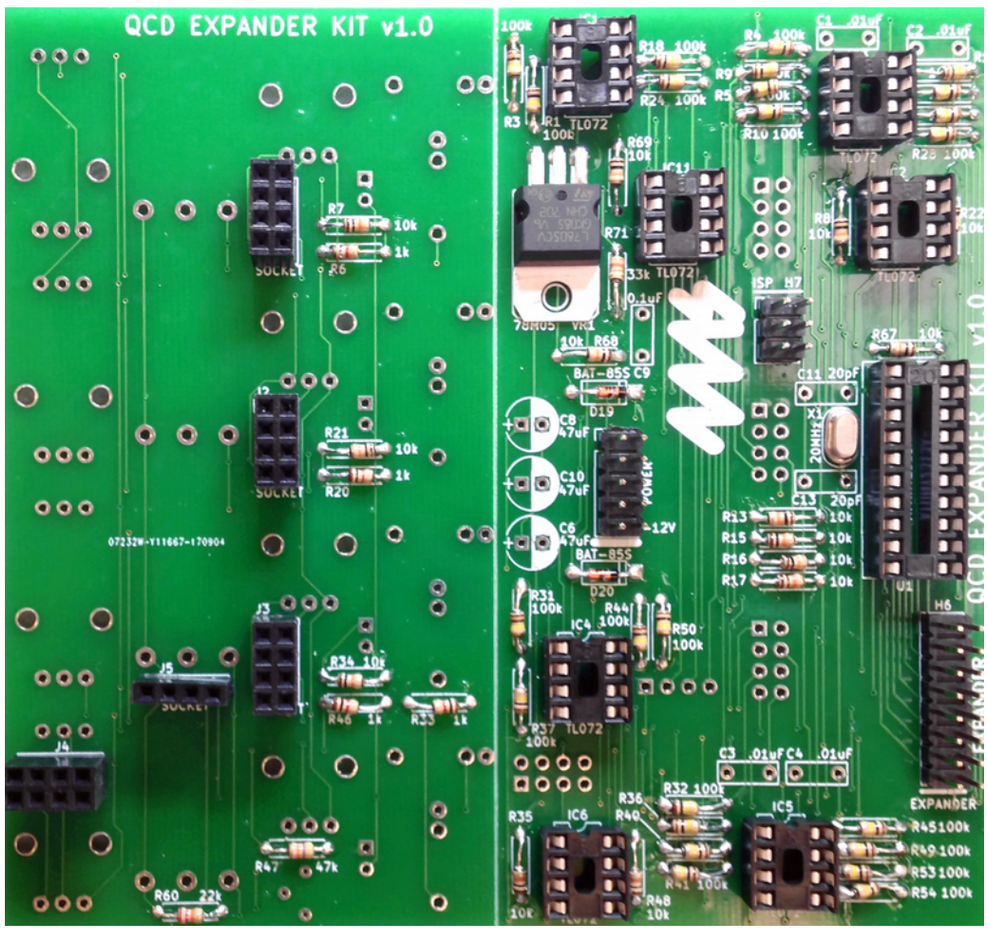
Solder one or two pins per header, then flip the board back over and check to make sure they are lined up, flush to the PCB, and the pins are at a perfect right angle to the PCB. When you verify this, flip the board back over and solder the rest of the pins.

- *2x8 headers x 1*
- *2x3 header x 1*
- *2x5 header x 1*



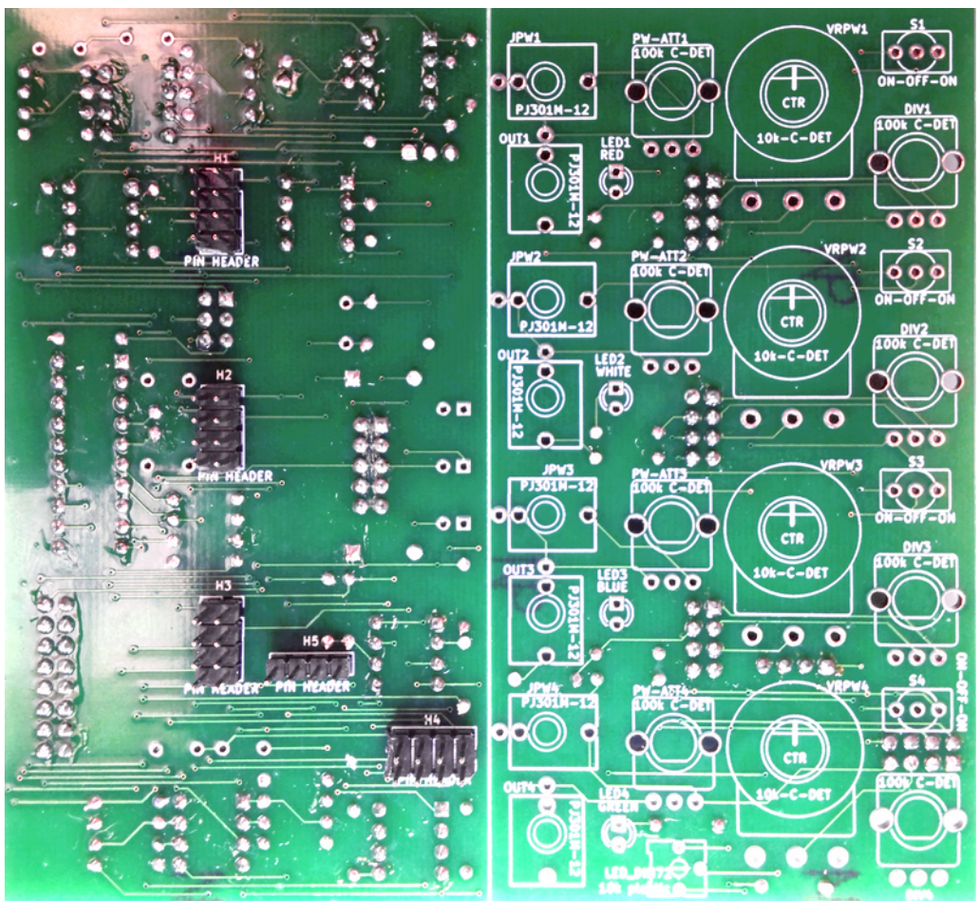
B. Insert the female headers as shown. **Make sure the header pins are flush and vertical-- your QCD EXP won't fit together if the header pins are not perfectly vertical!**

- *2x4 female headers x 4*
- *1x4 female header x 1*



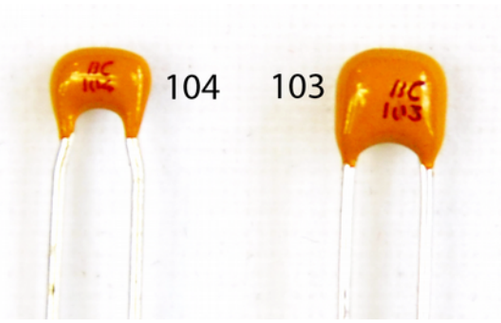
C. Insert the male headers as shown. Follow the tips in step 4B.

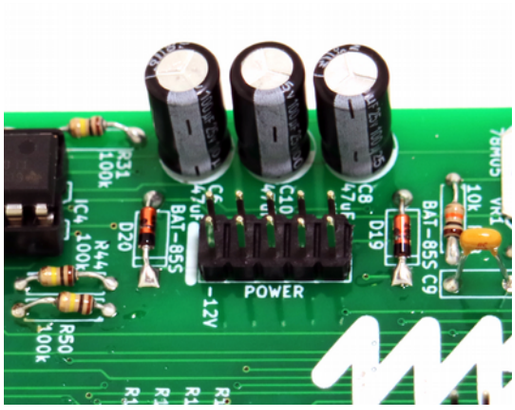
- *2x4 headers x 4*
- *1x4 header x 1*



Step 5: Capacitors

Insert and solder the capacitors. The 0.1uF, 0.01uF, and 20pF caps can go in either way, but the 47uF cylinder caps must go in with the long lead in the square hole.



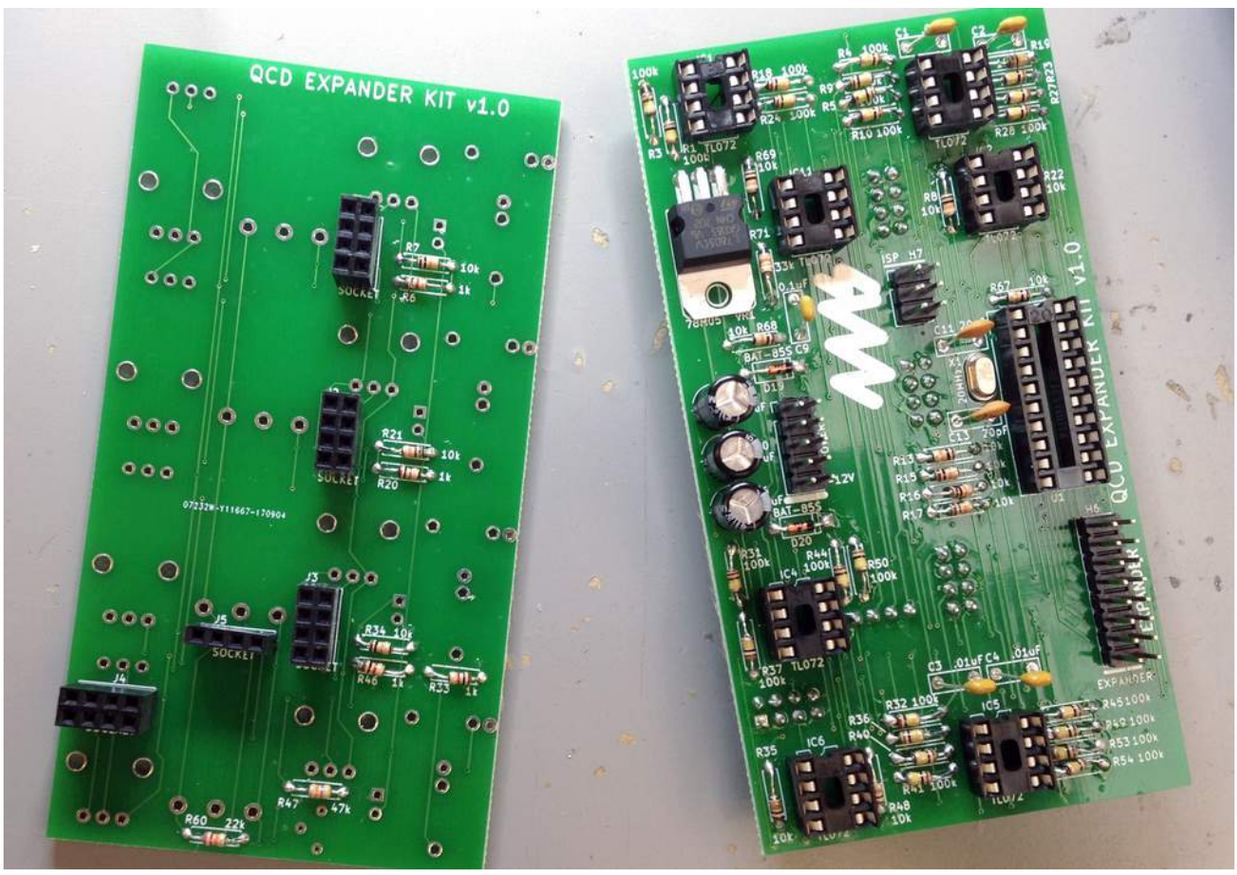


Above left: the 0.01 uF and 0.1uF caps are labeled "103" and "104" respectively on their faces. While they look very similar, the 0.1uF (on the left) is slightly smaller.

- *0.01uF (103) x 4*
- *0.1uF (104) x 1*
- *20pF x 2*
- *47uF x 3*
- *47uF x 3 (note the stripe orientation)*

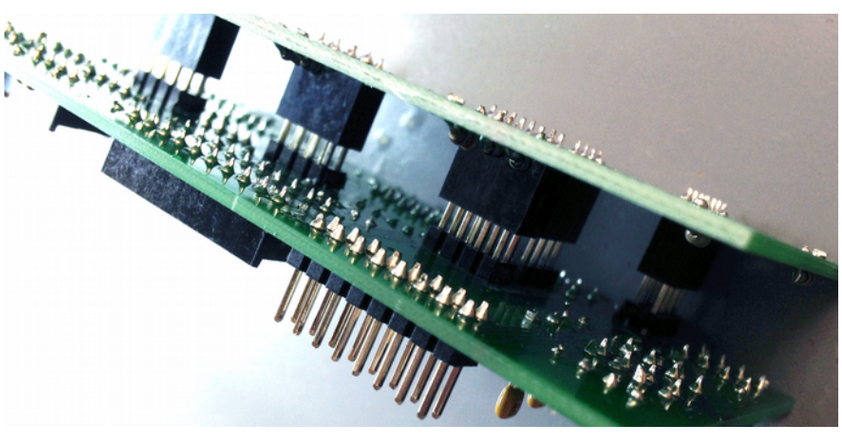
Step 6: Prep Mounting part 1

A. First, snap your boards apart. They are scored down the length, and you can just snap them apart with your hands. Be careful of the male header pins, as these will poke your hands if broken incorrectly.



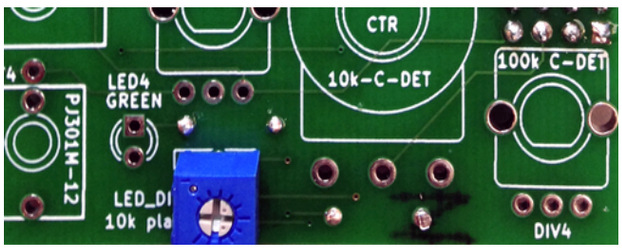
B. Lay the top board on the control board so that the header pins line up with the female headers.

C. Gently press the boards together. Verify that everything is straight, none of the headers are at an angle, and no pins are sticking out (see photo on right).



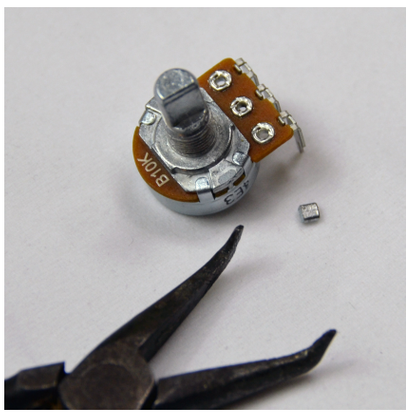
D. Take apart the boards, then insert and solder the 10k trimpot. The trimpot goes on the opposite side of all the other components.

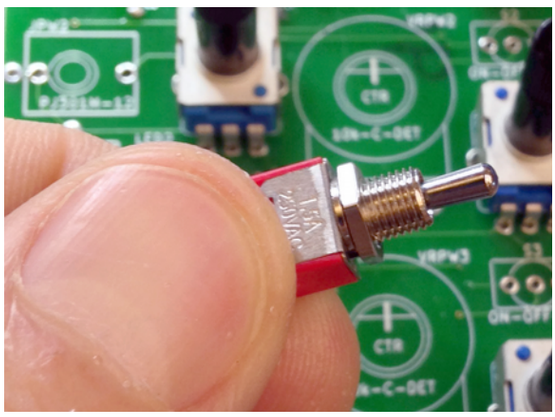
E. Take a minute to carefully inspect the bottom (control) board. Make sure every component is soldered, and that you didn't miss a joint. It's especially easy to miss a joint in the rows of header pins. **After the next step, locating and fixing a problem will be harder, so take the time now to check everything over.**



Step 7: Prep Mounting part 2

A. Bend the tabs off of the 16mm pots (see photo below) with your needlenose pliers. Place one washer on each potentiometer, this will ensure proper spacing and tightening during the mounting process.





B. Bend the tabs inward a bit, and insert the 9mm potentiometers into the PCB. Do not solder yet.

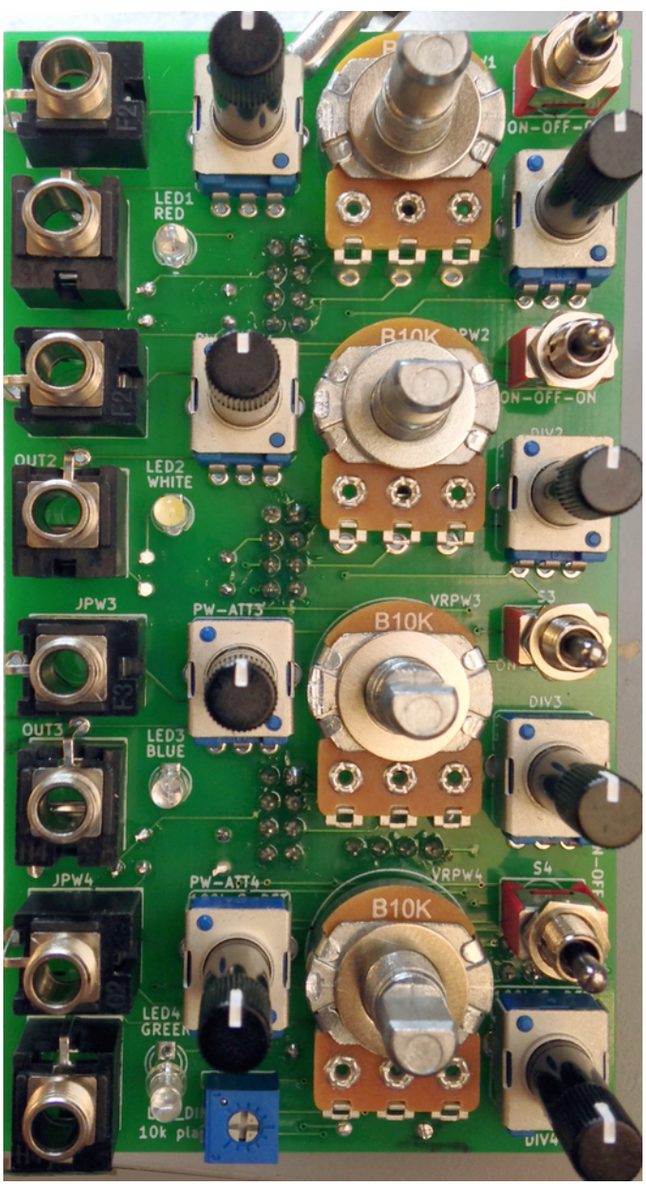
C. Insert the jacks into the PCB, make sure all pins are through their respective holes. Do not solder yet.

D. Insert the 16mm potentiometers into the PCB. Do not solder yet.

E. Install one nut at the base of each of the four switches (see photo above). Then insert into the PCB.

F. Notice the LEDs come color coded on a piece of paper. The one with milky off-white head is white, and the other three have clear heads. If these three become separated from the colored sheet they will be hard to discern from one another, so make sure to remove one LED at a time. Insert the LEDs into the PCB where marked. The longer lead goes in the square hole.

G. After inserting all 4 LEDs, verify the long lead is in the square hole. This is easy to mix up, and hard to fix later.

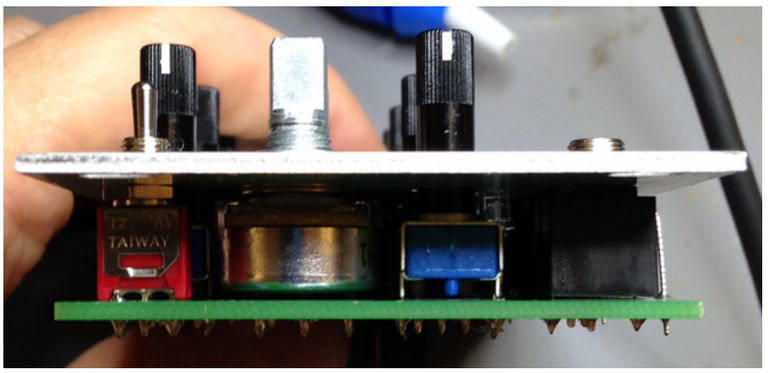


Step 8: Mounting part 1

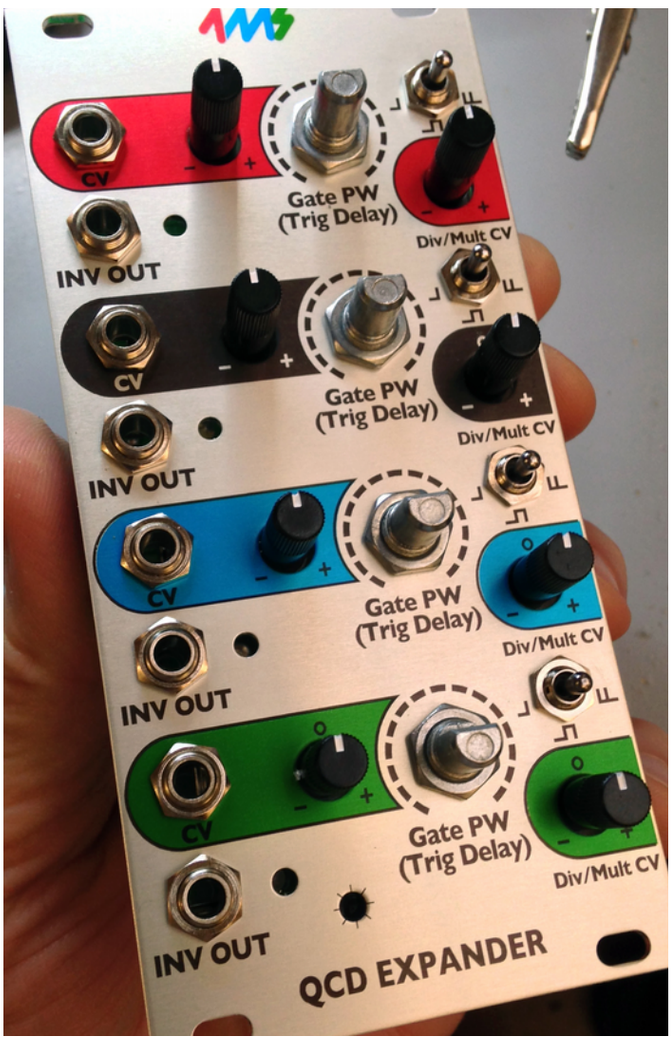
A. Remove plastic wrap from panel.

B. Push the LEDs down close to the PCB. Take the panel and gently lower it down on the PCB. Wiggle it slightly so that it fits over the pot shafts, then the jacks.

C. Once the panel is on, hold everything together with one hand while putting a nut on the corner jacks and potentiometers with the other hand. This is tricky and you may drop the nut a few times: don't worry, this is the hardest part. Tighten the nuts down **slightly (1/8 turn)** with a 5/16" (jacks), 3/8” (pots), and 1/4” (switches) socket or pliers (be careful not the scratch the panel!).

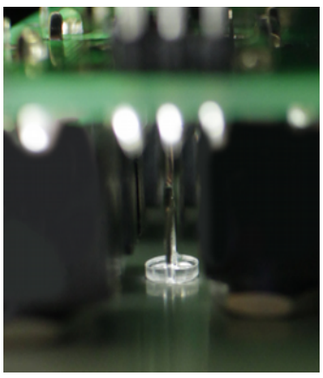


D. Flip it over and make sure there are no gaps between the jack and the PCB (see photo). Also, make sure the PCB is as close to parallel with the panel as possible. Now, install the rest of the nuts on the jacks, potentiometers, and switches. You can go slightly tighter than the 1/8 turn to get the panel to fit snug, now that we've verified the hardware is sitting flush to the PCB. The tension will keep the board and panel together. Be careful to only hold by the base (either direction when holding) or the two pieces will come apart.

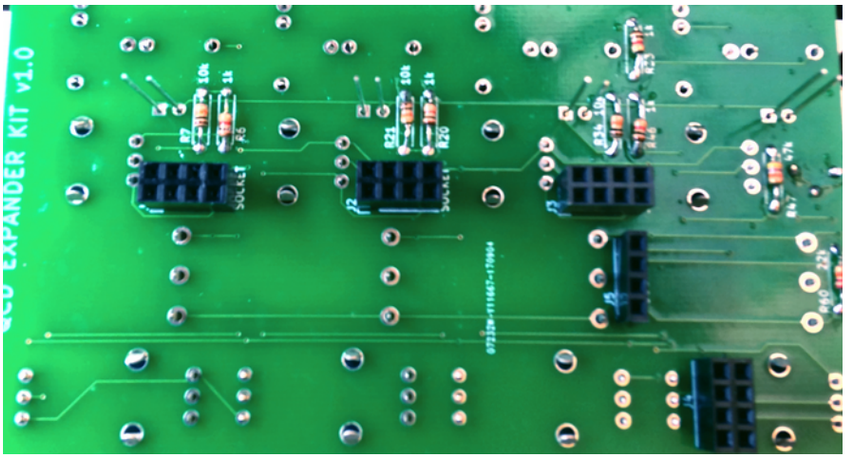


Above: Step 8D Install the remaining hardware on the panel. When you flip the module over before soldering, be careful the two parts stay together. Place against a hard surface or in a vise.

Step 10: Mounting part 2



A. Hold the unit so the panel is facing the floor. Gently guide the LEDs by their leads so their heads fit flush into the holes in the panel (see photo on left). Once positioned, you may want to slightly splay their leads so they stay in place.



B. Flip module over and place on a hard surface or in vise to solder. (see photo above)

C. Now solder one joint on each component:

- One lead of each LED (either one)
- The center pin of each 16mm and 9mm potentiometer
- Either the left or right lug pin of each 9mm potentiometer

D. Flip the unit over and tighten down the potentiometer nuts with your 3/8” driver or pliers. Now install the 4 knobs on the pot shafts. Notice how the pot shafts have a D shape, as well as the inside of the knob.

E. Move each knob so that it's centered within the panel artwork (see photo on right). If the center detent of the pot does not match the center point on the panel silkscreen (in this case the noon hashmark, see photo), you may have to loosen the pot nut and reposition it. Try holding or pushing the shaft of the pot in the direction you need it tweaked, while tightening down, using your needlenose pliers, with the other hand. If you have trouble pulling the knobs up by hand to loosen the pot nuts, you may have to pry them up with a tool. If this is the case make sure you don't scratch the panel, or damage the knobs. A small screwdriver acting as a lever with a soft cloth underneath to prevent scratching of the panel should suffice.

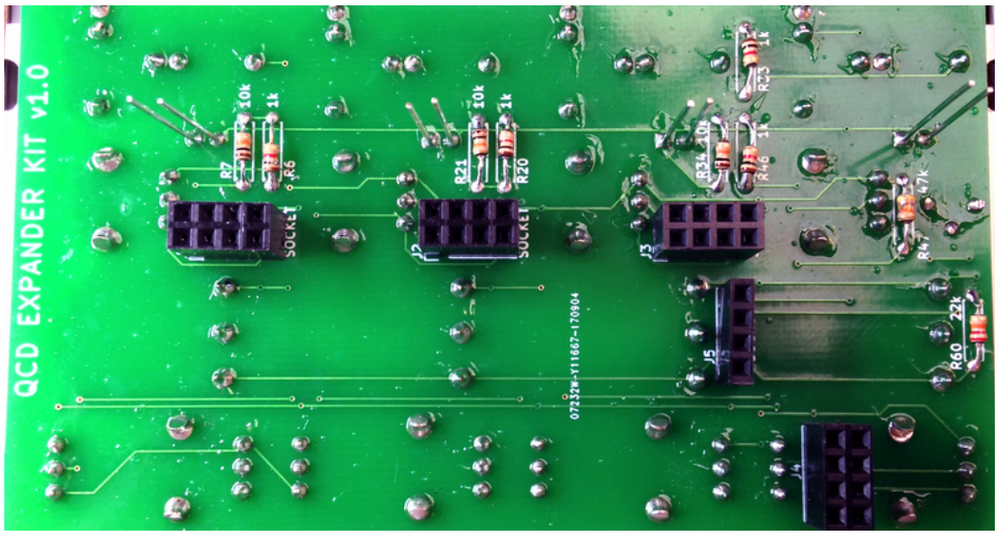
F. Move each 9mm potentiometer and make sure it is centered on the O mark (see photo on right). If not, heat up the pin you soldered in step 10C, and center the pot with your hand. It will help to hold the module in your hands rather than against a surface or in a vise.

G. Verify that each LED is visible through its hole in the panel. If necessary, re-position by heating up the one pin you soldered in step 10C.

H. Verify that your four switches are not poking out of the PCB.

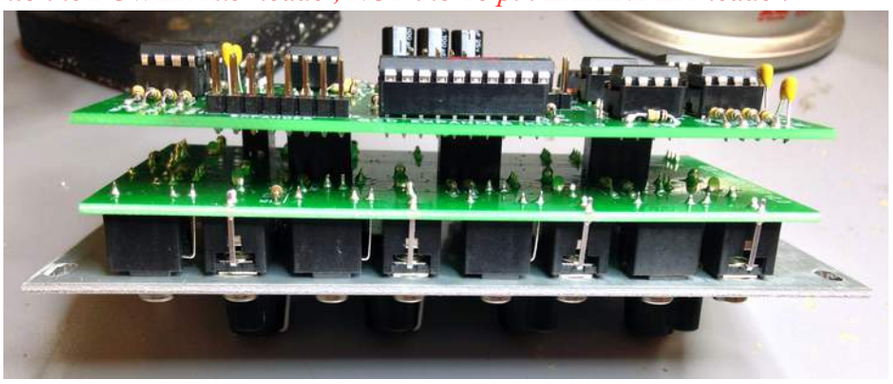
I. When you're sure all the pots, jacks, switches and LEDs are all placed perfectly, you can go ahead and tighten all the nuts down (careful not to scratch the panel!)

J. Check all the pots, buttons, and LEDs a third and final time, and then flip the unit over and solder the rest of the PCB (all jacks, pots, buttons, and LEDs). Snip the LED leads short.



Step 11: Finishing touches

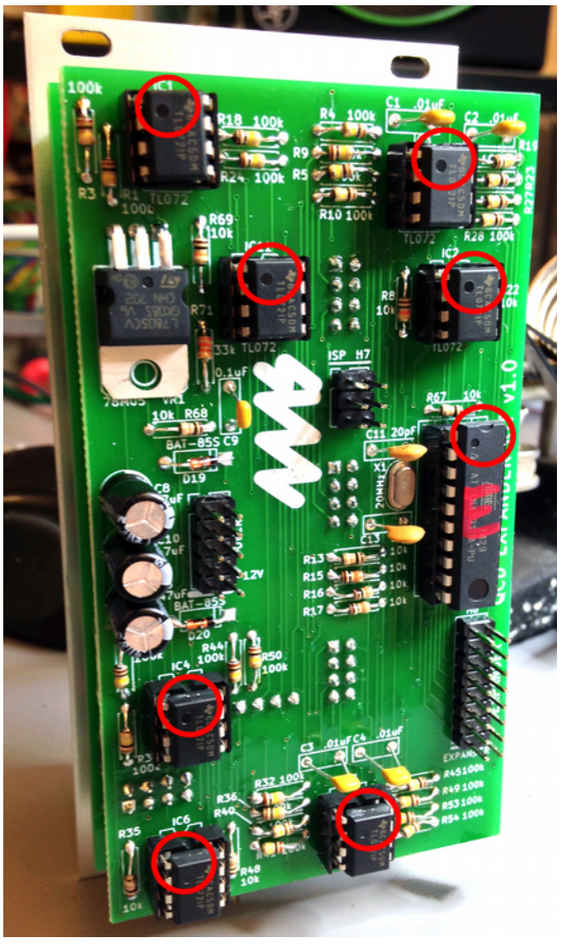
Put the two PCBs together: just like you did before in step 6. Push firmly so the pins go all way into the headers and no metal is exposed on the pin. *Install the 10-pin ribbon cable with the red stripe at the bottom (-12V) onto the POWER 2x5 header, NOT the 16 pin EXPANDER header.*



Step 12: Insert ICs

Each IC has an orientation, the dot or notch should be pointed towards the notch in the IC socket. Verify you didn't put the IC socket in backwards by checking that the IC notch/dot lines up with the notch drawn in white on the PCB. See photo (the red circles indicate the notch/dot).

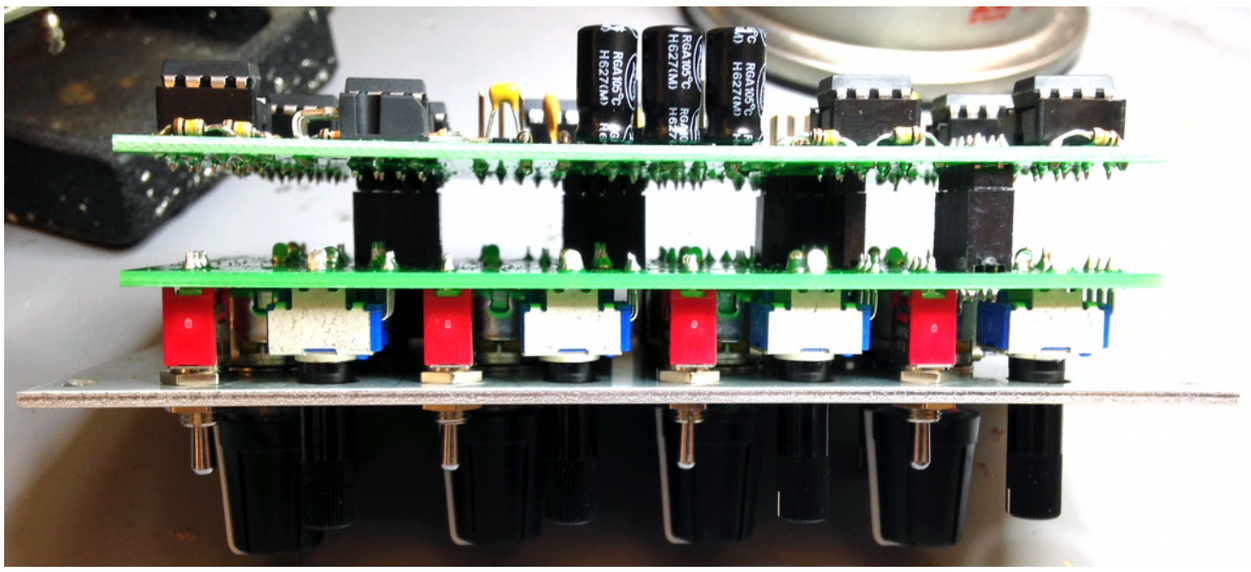
- *TL072 (8-pin) x 7: (all notches facing up)*
- *ATTNY2313 (28-pin) x 1: (notch facing up)*



Step 13: Take a break

That's right, walk away and do something else. This is a critical step **especially if you are an advanced kit builder or electronics person** (beginners tend to check their work with more skepticism!). There are many things you can do wrong in building a QCD Expander that causes it to smoke and destroy components. So don't rush, have a clear head, and check your work. Come back refreshed. Look over everything:

- Check all the solder joints, it's easy to miss one.
- Verify the ICs and IC sockets are not in backwards.
- Verify the diodes have the band pointing to the line on the PCB
- Verify the 47uF caps are not in backwards (stripe to the right).
- Verify the header pins are not bent.
- Verify no components are sticking up and potentially able to short out to something.



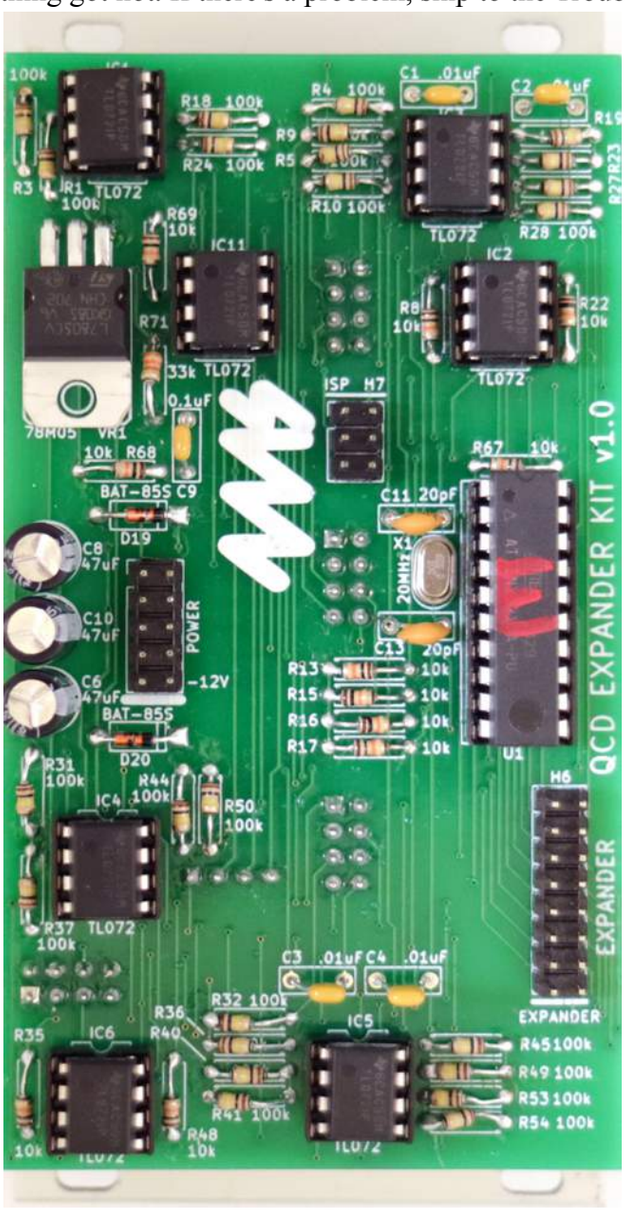
Step 14: Power up and calibration

Make sure to plug the power cable into the 2x5 header, NOT the 2x8 EXPANDER header. If you connect the EXPANDER header to power, it will DAMAGE THE MODULE.

Use the supplied 10-to-16pin power cable to attach the 2x5 “POWER” header to a standard Eurorack power supply. The red stripe on the cable should be down, matching the white stripe on the PCB.

Before turning on the power supply, use the 16-to-16pin cable to attach the EXPANDER header on the QCD Expander to the EXPANDER header on a QCD module. The red stripe should be orientated down on both the expander and the main module.

Power up, and tap the QCD's button to set a tempo. The lights on the QCD Expander should flash. If not, unplug immediately and check around for errors. Make sure both cables aren't backwards. Feel all the ICs and the 7805 to see if anything got hot. If there's a problem, skip to the Troubleshooting section.



Test Procedure

1. Attach the 10-pin end of a 10-to-16 pin cable to the 2x5 POWER header, and the other end to a Eurorack power supply.
2. Attach one end of a 16-to-16 pin cable to the EXPANDER header, and the other end to the EXPAND header on a QCD
3. Screw both modules into the case (optional)
4. Turn the power on
5. Tap the QCD's button twice, perhaps half a second between taps.
6. Set all QCD Div/Mult knobs to center "=".
7. Set all QCD Expander knobs to center (all 12 knobs).
8. Set all switches to center position
9. Plug the red channel's INV OUT to an oscilloscope
   If you don't have a scope, you can patch into the FM input of a VCO and use your ears to listen to the difference in time the VCO spends being high vs. low
10. Check the duty cycle of the waveform.
    What is duty cycle? Duty cycle is the time spent being high vs. the total time spent being high or low. If the duty cycle is 50%, then the high and low times are equal, and the waveform is a square wave.
11. Make sure the red channel Gate PW knob and the CV PW attenuator are centered
    The unlabeled potentiometer on the QCD Expander is the CV PW attenuator (it's the small knob to the left of each large Gate PW pot).
12. You should see the duty cycle be 50% (42% to 58% is ok)
13. Turn the Gate PW knob all the way to the left. Verify the duty cycle is about 7%
14. Turn the Gate PW knob all the way to the right. Verify the duty cycle is about 90%
15. Turn the Gate PW knob back to center. The duty cycle should go back to about 50%
16. Turn CV PW attenuator all the way right, then all the way left. Verify that the duty cycle does not change.
17. Use another module to generate a DC offset voltage of about +5 volts (use a multimeter to verify the voltage is between 4V and 6V; anything in that range is ok)
    1. +5V can be generated using a SISM channel: adjust the SHIFT knob to get +5V
    2. Or, a MATHS channel 2 or 3 can generate a DC voltage
    3. Or, many CV sequencers can generate a DC voltage
    4. Or, a PEG channel with Cycle turned off, Bi-Polar turned on, and Scale set fully CCW (all the way down to the left) will generate about +5V on the main ENV jack
18. Patch the +5V into the red channel CV jack (left side of the QCD Expander)
19. Turn the CV PW attenuator to the center. Verify the duty cycle is still about 50%
20. Turn the CV PW attenuator all the way right. Verify the duty cycle is about 90%
21. Turn the CV PW attenuator all the way left. Verify the duty cycle is about 7%
22. Unplug the CV jack
23. Test the switch:
    1. To the left, you should see a 5ms trigger
    2. At center, you should see the familiar 50% duty cycle square wave
    3. To the right, you should see twice and many 5ms triggers as to the left. If you turn the big Gate PW knob to the left or right, you should see a variable shuffle pattern (every other trigger moves closer to the previous trigger).
24. Flip the switch to the left (single trigger).
25. Plugging the +5V DC voltage (from step 14) into to Div/Mult CV jack on the main QCD module. The Div/Mult CV jack is the unlabeled jack immediately to the right of the Div/Mult knob on the QCD.
26. Slowly turn the Div/Mult CV attenuator knob on the QCD Expander up. As you turn it up, you should see the frequency of the pulse wave go to x2, then x3, x4, x5, x6, x7, x8, x12 and finally to x16
27. Slowly turn the Div/Mult CV attenuator down from noon and you should see the frequency divide from /2, /3, /4, /5, /6, /7, /8, /16, /32
    1. You may need to adjust the overall QCD timing to make it easier to recognize the slower speeds.
28. Repeat steps 9-24 for each channel (black, blue, green).
29. Using a small Phillips-head screwdriver, adjust the LED Dimmer trimpot to set your LED brightness preference

Calibration Procedure

Calibration is completely optional. The only reason to spend time calibrating is if you require more precise duty cycles and Div/Mult CV response. There are natural variations in the resistance value of the potentiometers when they are set to the center detent position. The calibration procedure compensates for these variations. Again, its completely optional and should only be performed once the unit is verified working 100%. Calibration should only be preformed by advanced electronics people comfortable with soldering, making resistance measurements (never in-circuit!) and measuring things like duty cycle and frequency.

If you notice that any of the potentiometers are not centered in value when physically centered, you can adjust them by soldering resistors across their pins. For instance, if the duty cycle is 60% when the Gate PW knob is centered, you may optionally change this to 50% by soldering a large value resistor between lugs 1 and 2 of the Gate PW pot. If it was 40% when you wanted 50%, then solder the resistor to lugs 2 and 3.

For the resistor value, start by trying a value of 1M, then try 680k, 470k, 330k, 220k, and 100k. If the issue gets worse when you solder a resistor on, then you soldered to the wrong lugs (ie 1 and 2 instead of 2 and 3). You could also solder two lugs of a 1M pot to the Gate PW pot and adjust the pot until you get the expected response. Then remove the pot, measure its value, and replace with a resistor of the same value. Another approach is to solder trimpots

Troubleshooting

If something in the testing section isn't working, continue the entire test procedure and take notes of what doesn't work.

1. Verify all ICs are correctly orientated.
2. No LEDs turned on? Make sure you turned the LED dimmer trimpot to center. Still no LEDs? Verify if you have a pulse wave output on the INV OUT jacks. If so, then the module is working and perhaps you just put the LEDs in backwards.
3. No LEDs and no output from INV OUT jacks? See if the Div/Mult CV attenuator pots work. Patch CV into the QCD's Div/Mult CV jack and see if adjusting the attenuator on the Expander changes the response in frequency to the incoming CV. If so, then the Div/Mult CV attenuation section is working, but the Pulse Width section is not working. A likely culprit is something on or around the ATTINY2313 IC
4. If one or more channels doesn't work, but at least one channel does work, then you can rule out a bad ATTINY2313 chip.
5. If a switch doesn't seem to work, verify the pins are actually going **through** the PCB.
6. **Check for bad joints.** The number one cause of problems is bad solder joints. Even experienced kit builders miss a pin, or short two pins together. Take 5-10 minutes right now to inspect each and every joint. Remove the faceplate if necessary. When you're done, if you still have problems, a good procedure is to re-flow each joint. This forces you to visually inspect the joints. It often results in the unit “magically” working!
7. **Check for component errors**. The number two cause of problems is wrong components in the wrong place, or backwards components. Backwards chip? Backwards diode? Check again, it's easy to do! IC socket pins have a tendency to bend under rather than go into the hole, so check all the pins on the socket went through the PCB, and that the pins on the IC itself went into the socket.
8. *Note:* While an easy scapegoat, it's extremely rare for the cause of problem to be a bad component. Resistors, caps, and diodes are very very rarely damaged without obvious visible evidence (ie, they look like burnt toast). However, ATTINY chips can get zapped. Make sure to install this chip last, and keep in ant-static bag and foam until used.
9. **Measure voltages on the chips**:
    1. Set the voltmeter to measure DC voltage (not AC).
    2. Hold the black lead of the voltmeter to ground. An easy place to find ground is the large tab on the 7805.
    3. Verify the voltages:

    ATTINY2313: Pins 1 and 20 = +5V; Pin 10 = 0V (ground)
    7805: Pin closest to center of board=+11.6V; Middle pin=0V, Pin closest to edge of board=+5V
    TL072 (all seven ICs): Pin 8 = +11.6V; Pin 4 = -11.6V
    (Google “IC pin numbering” if you don't know how to count IC pins!)
10. If something got hot when you powered up (especially the 7805), remove all the ICs from the sockets before powering up again. Then see if the 7805 is still getting hot. If it is, check for shorts anywhere on the board. If it's not getting hot, insert the ICs one at a time and see which one makes it start getting hot.

Don't give up!!