extralife instruments

# Super Sixteen Build Guide

Guide v1.1 - April, 2021

## CPU Board (smaller PCB)

1.1 - Resistors

Install the through-hole resistors by bending the leads and inserting them through the vias, bending the leads, flipping the PCB, and soldering them. They can go in either way but it's good to keep all the color codes facing the same way.

1. Install the twelve **1K** (1 kiloohm) resistors (brown, black, red, gold)
    R103, R104, R105, R106, R107, R108, R109, R110, R111, R112, R113, R116

2. Install the five **10K** resistors (brown, black, orange, gold)
    R102, R114, R115, R117, R118

3. Install the one **1M** (1 megaohm) resistor (brown, black, black, yellow, brown) (blue body)
    R101
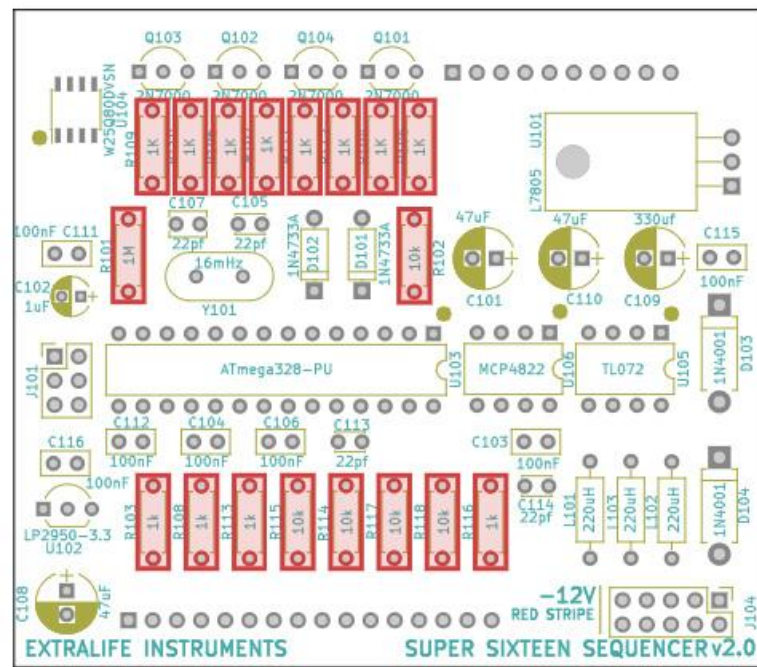
*Install the resistors in this step in the highlighted locations.*

1.2 - Diodes
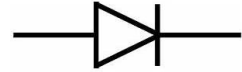
Install the diodes like the resistors, but be careful that they are **polarized**. The stripe on the diode body must match the stripe on the PCB silkscreen.

1. Install the two **1N4001** diodes - larger black plastic diode with silver stripe.
   D103, D104

2. Install the two **1N4733A** zener diodes - larger red glass diodes with a black stripe.
   D101, D102

   *Set aside the **BAT85** diode (smaller red glass diode) - it goes on the other PCB*
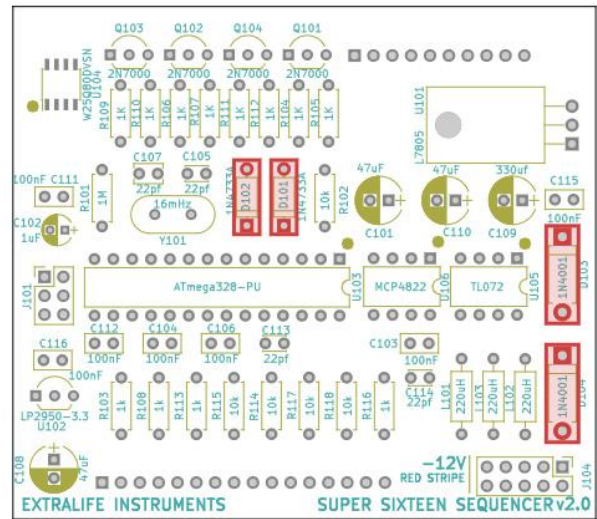
1.3 - Ceramic capacitors
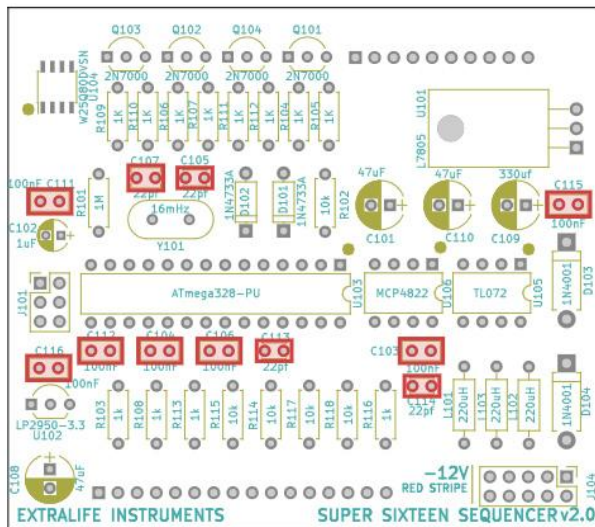
Install the ceramic caps - they are non-polarized, so don't worry about which way is which. Just be careful to use the right values because they look similar to one another!

1. Install the four **22 pF** capacitors (code 22J)
   C105, C107, C113
   and C114 (optional),

2. Install the seven **100nF / 0.1uF** capacitors (code 104)
   C103, C104, C106,
   C111, C112, C115, C116

1.4 - ICs / Chips

First, install the smallest IC - the Winbond **W25Q80DV** flash memory chip (U104) in the corner of the PCB. This is an SOIC-8 surface-mount package. It is the only surface-mount part in the project. It comes in a small black plastic tray which is a piece of a "reel" of chips.
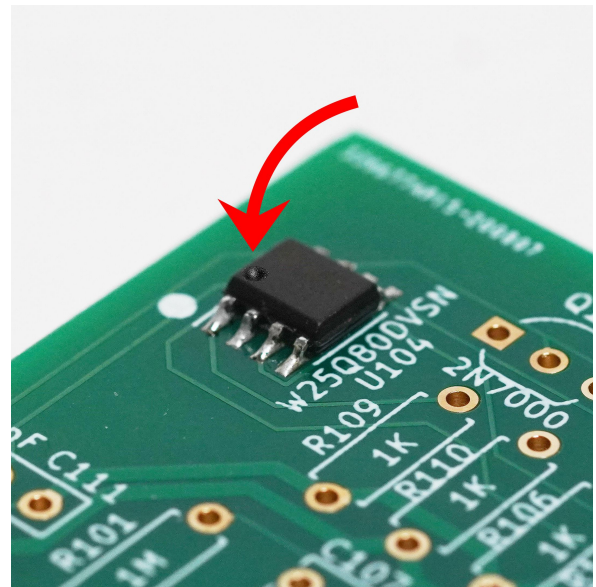
1. "Tin" **only one** of the IC's pads on the PCB by applying a small amount of solder to it.

2. Using tweezers, peel off the clear plastic protective film and remove the IC from the reel.

3. Locate the "dot" in the corner of the chip indicating which pin is Pin 1. Match this to the dot on the PCB silkscreen to orient the chip properly. (see photo)

4. Hold the chip with tweezers and place it on the pads in the correct orientation. At the same time, heat the tinned pad with the soldering iron to "tack" the IC in place. Hold it down with the tweezers to make sure the IC sits flat against the board while the solder cools.

5. Apply soldering flux on the legs of the IC and its pads.

6. Apply some solder to the end of the iron, then touch that liquid solder to IC legs and pads to flow solder into the joints using the pre-applied flux.

7. If solder bridges form between pads, remove them using additional flux and a clean iron tip, or use solder wick (aka desoldering braid).

Next, install the larger through-hole ICs. Straighten the legs of each IC by pushing them against a flat surface. Insert them into the PCB and be careful to install them in the **correct orientation** by matching the "divot" and/or "dot" at one end of the IC with the matching symbols on the PCB silkscreen. If the chip falls out when the board is upside-down, bend over the corner legs with a screwdriver so it stays in place for soldering.

1. Install the **ATMega328P-PU** microcontroller, the large 28-pin IC. (Be careful not to confuse it with the MCP23S17, another 28-pin chip which goes on the other PCB)
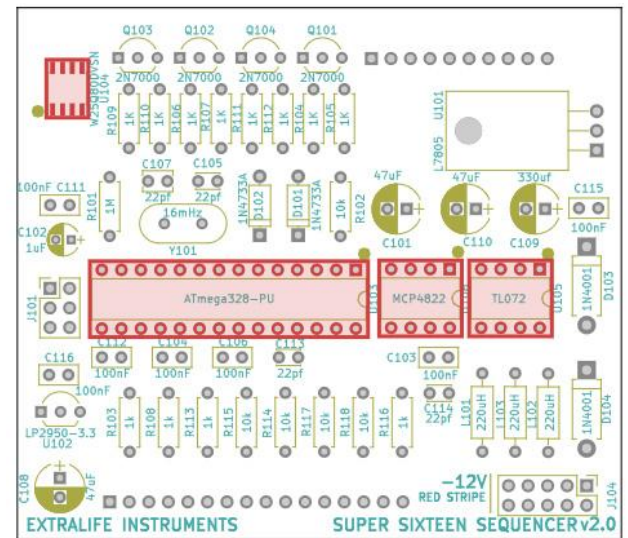   U103

2. Install the **MCP4822 DAC**. It is the same size as the next IC, so be careful to read the labels and get both of them in the right place.
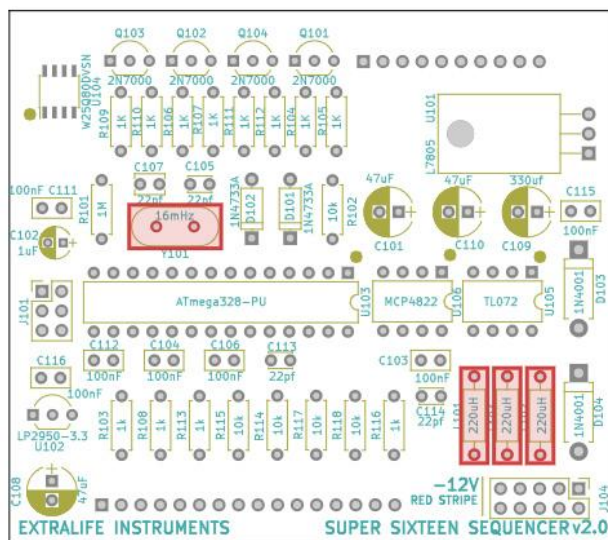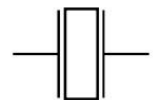   U106

3. Install the **TL072** op-amp.
   U105

1.5 - Crystal & Inductors (other)

Install the quartz clock crystal and inductors. The crystal comes in a metal can, and the inductors look like large resistors with a darker color. Neither of them is polarized.

8. Install the one **16mHz crystal**
   Y101

9. Install the three **220uH** inductors
   (red red brown gold)
   L101, L102, L103

1.6 - Transistors and Regulators

Install the small TO-92 package transistors by inserting them into the board, bending the leads out, and soldering them. The **flat side** of the device must match the flat side on the PCB silkscreen.
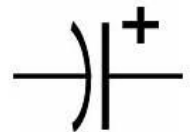
1. Install the four **2N7000** MOSFET transistors
   Q101, Q102, Q103, Q104

2. Install the one **LP2950-3.3** voltage regulator
   U102

On the larger TO-220 package regulator, b**end down each of the leads** until they sit at a right angle to its body. This will allow you to mount it flush against the PCB.

1. Install the one **LM7805** 5V voltage regulator
   U101
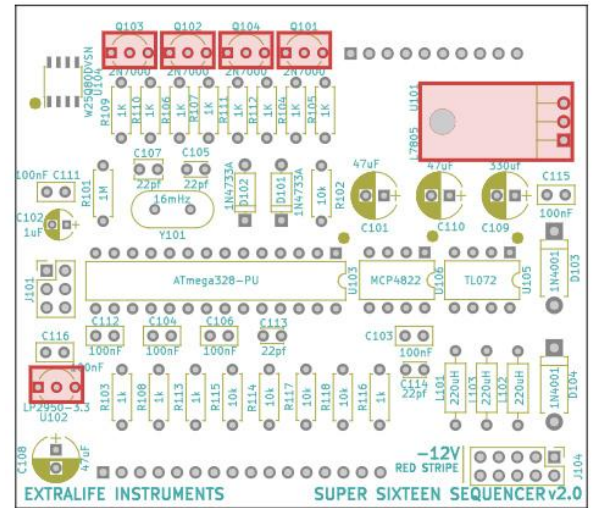
1.7 - Electrolytic capacitors

Electrolytic capacitors are polarized! Install them by matching the white stripe the white semicircle on the PCB silkscreen.

1. Install the three **47uF** capacitors
   C101, C108, C110

2. Install the one **1uF** capacitor (C102)

3. Install the one **330uF** capacitor (C109)
   Note: If you have a very tall 330uF capacitor, bend its leads first so it can lean over and lay flat against the nearby IC (U105) and hot-glue it in place. This will let the module fit in smaller cases.
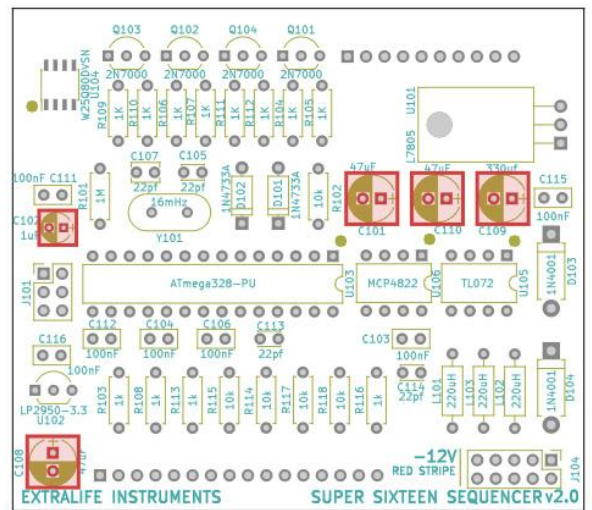
1.8 - Pin & socket header connectors

The **dual-row** connectors for power and ICSP, **J101** and **J104** are installed on the top of the PCB and soldered on the back, like the other components on the board. It can be tricky to get them to stay in place. The easiest way is to use alligator clips, hemostats or locking tweezers. Alternately, you can mount them using tape, solder them in place, and remove the tape. If you have a **keyed** (aka **shrouded)** 10-pin power connector (J104), the key (or notch) should face toward the lower **edge of the PCB.**
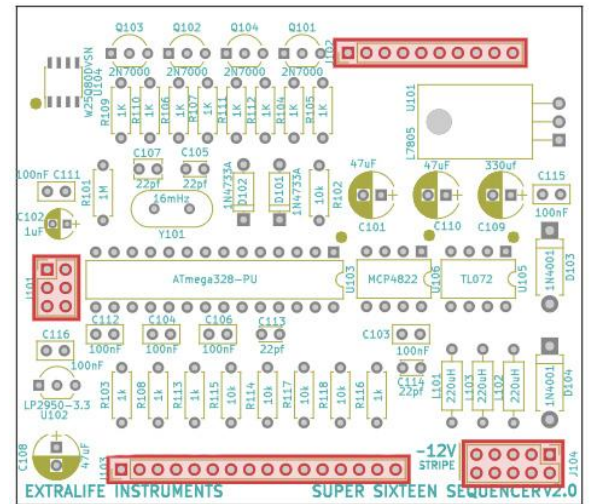
1. Install the two **dual-row** header connectors.
   J101, J104

The **single-row headers** connect the 2 PCBs together. They (J102, J103) are installed on the **underside** of the PCB and s**oldered on the top**. It's easiest to install them by **mating the header pins to the sockets**, and loosely fitting them in both PCBs at once to ensure they go in straight.

Place the Control board in your PCB holder, and loosely install the mated header sockets in their positions on the backside of that PCB (J1, J2). Then set the CPU board on top and fit the pins through so both connectors are held in place and parallel. Level both of the boards so the headers sit straight up and down.

1. Solder the header connectors on the **top** side of the CPU board.
   J102, J103

Carefully remove the boards from your PCB holder and flip them over so you can access the top of the Control board.

2. Solder the header connectors on the **top** side of the Control board.
   J1, J2

Gently prise the PCBs apart by hand, being careful not to bend or damage the header pins. Then **take a break**! You're halfway there!
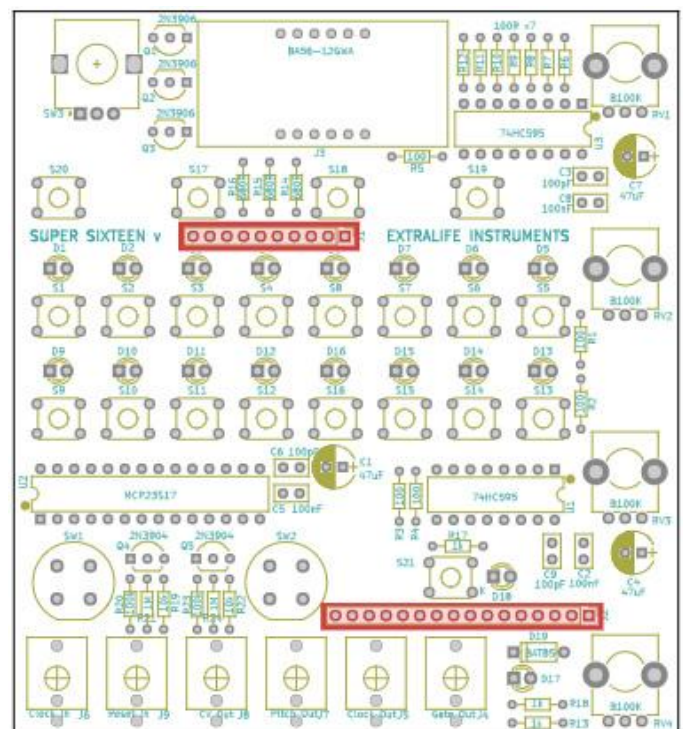
Control Board (larger PCB)

NOTE: You should have already soldered the pin headers
on the Control PCB in the previous step!

2.1 - Resistors

Install the through-hole resistors on the Control Board.

1. Install the twelve **100 ohm** resistors
   (brown, black, brown, gold)
   R1, R2, R3, R4, R5, R6, R7, R8, R9, R10,
   R11, R12

2. Install the three **680 ohm** resistors
   (blue, grey, brown, gold)
   R14, R15, R16

3. Install the three **1K** (1 kiloohm) resistors
   (brown, black, red, gold)
   R13, R17, R18

4. Install the two **10K** resistors
   (brown, black, orange, gold)
   R19, R22

5. Install the two **100k** resistors
   (brown, black, yellow, gold)
   R20, R23

6. Install the two **1M** (1 megaohm) resistors
   (brown, black, black, yellow, brown) (blue body)
   R21, R24
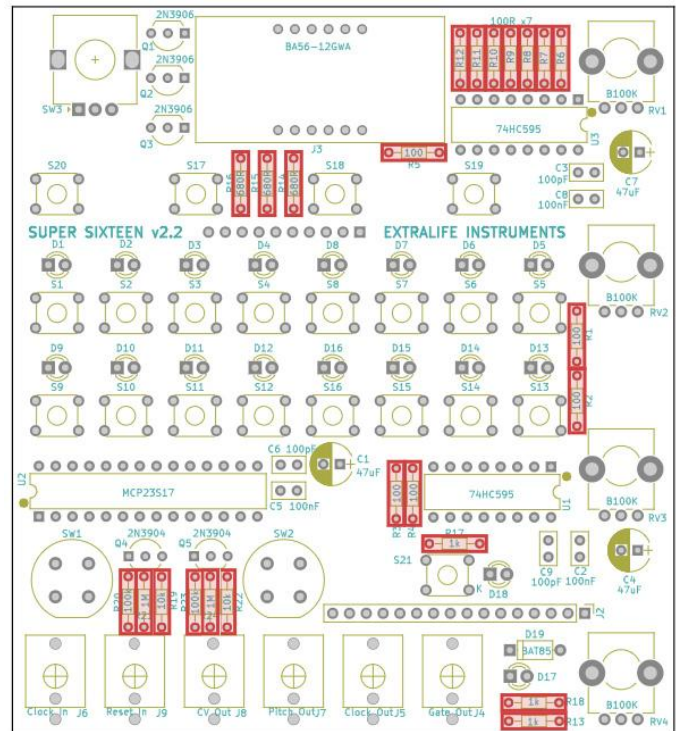
2.2 - Ceramic Capacitors and Diode

Install the ceramic capacitors and the one remaining diode. Near each IC you'll place a pair of two ceramic caps, one 100nF and one 100pF. The BAT 85 diode mounts near the bottom of the board, between the gate output jack and the potentiometers.

1. Install the three **100 pF** capacitors (code 101)
   C3, C6, C9

2. Install the three **100nF** / **0.1uF** capacitors (code 104)
   C2, C5, C8

3. Install the one **BAT85** diode (note the **polarity** and match the stripe on the diode to the stripe on the PCB)
   D19
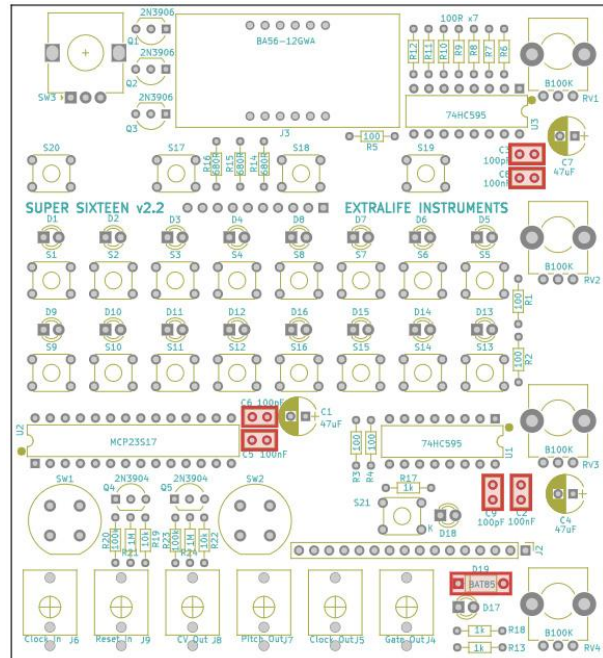
2.3 - ICs / Chips
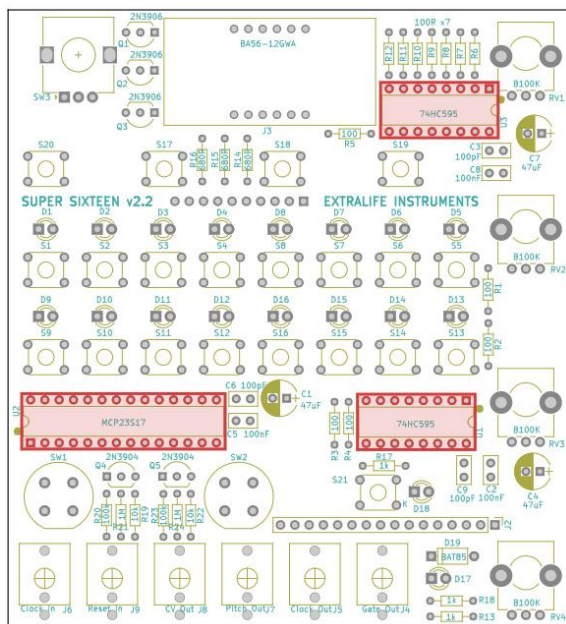
Install the three through-hole ICs. Note that the orientation of the large **MCP23S17** IC is **opposite** from the other two ICs. Match each IC so the **notch** at one end matches the notch on the PCB silkscreen.

1. Install the one **MCP23S17** I/O expander IC
   U2

2. Install the two **74HC595** shift register ICs
   U1, U3

2.4 Transistors

NOTE - Updated April 2021

The transistors are easy to install - just bend the leads, and solder as usual. However, please take note of the orientation of the **2N3906** transistors, which may not match the silkscreen.

On PCBs labeled **version 2.2 and earlier**, the silkscreen orientation is reversed. While the seven-segment display *will still work* with reversed transistors, it will be much less bright.

On **all versions** of the PCB, the 2N3906 transistors should be installed with the flat side facing *away* from the top edge of the PCB. This will greatly increase the display brightness (and also the electric current usage of the module - adding roughly 60mA at peak).
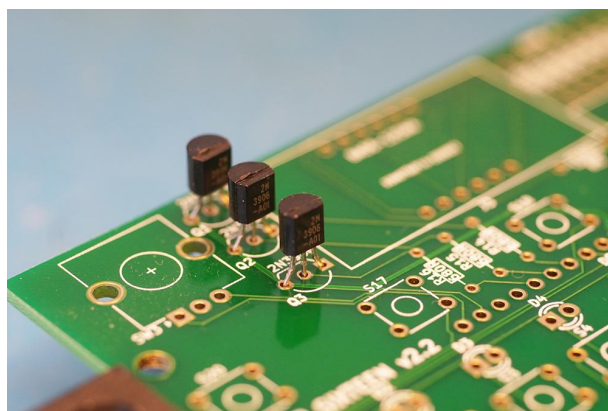
The 2N3906 transistors in the photo above are installed in the **correct orientation** on a v2.2 PCB with incorrect silkscreen.

1. Install the three **2N9306** transistors next to the display, with the flat side facing away from the top edge of the PCB.
   Q1, Q2, Q3

2. Install the two **2N3904** transistors next to the large IC, orienting them as marked on the silkscreen.
   *Q4, Q5*
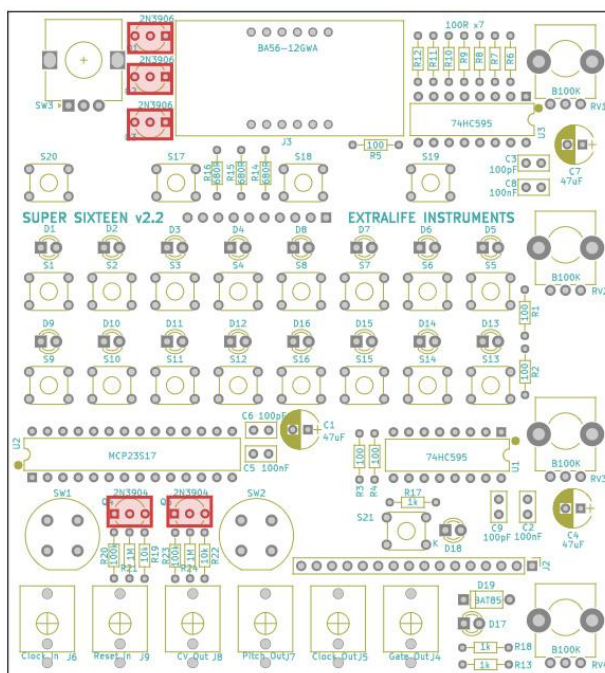
2.5 - Tactile Switches

Next you can install *all twenty-one* 6mm tact switches. It's very important that they all sit **flat** against the PCB so that the button caps line up properly with the front panel. Push them down and they should "click" against the PCB as the "gull-wing" bent leads should hold them firmly in place. The leads can sometimes be bent during transit so don't force them too hard, and bend the leads gently back into position if necessary.

This step requires making **84** individual solder joints! Take it slow and take a break in the middle.

1. Install the twenty-one tactile switches
    S1, S2, S3 … S21
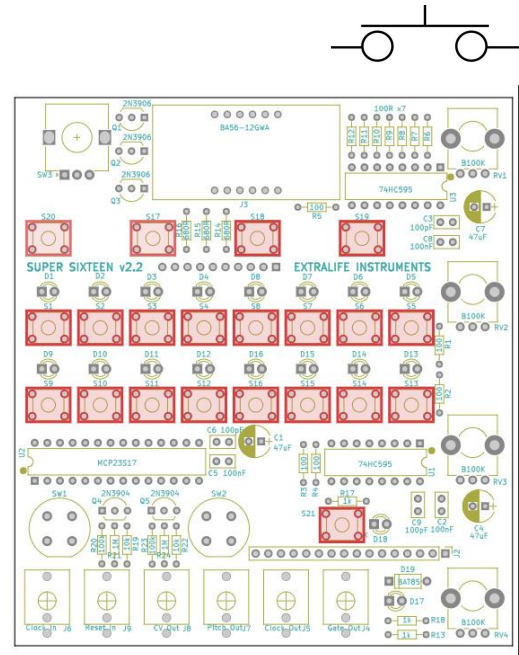
2.6 - Potentiometers, Encoder, Hex Standoff

At last, it's time to install the through-panel components! The potentiometers and encoder should be installed into the PCB, and then aligned using the **front panel** before and during soldering. Otherwise it is possible to misalign the pots, and it will be very difficult to fix!

Before fitting the front panel, install the 10mm hex standoff via an M3 screw in the hole just below the encoder (see diagram). This will keep the panel at the proper height and angle.

1. Install the hex standoff near the encoder (*SW3*)

2. Press-fit the encoder and potentiometers into place. You may have to bend the mounting tabs inward slightly.

3. Install the **front panel,** clamp it in your PCB holder and flip the assembly over. If you don't have a PCB holder, install the **hex nuts** on the potentiometers and the **M3 screw** into the hex standoff to hold the panel in place during soldering. **Do not** put a hex nut on the encoder.

4. Solder the 3 control pins of each potentiometer and the rotary encoder.
   *SW3, RV1, RV2, RV3, RV4*
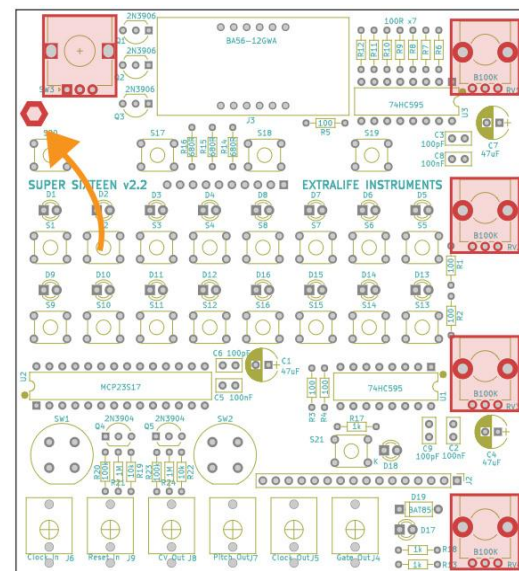
2.7 - 3.5mm jacks

Remove the **front panel** and set the PCB on a flat surface. The **WQP518MA** jacks have 3 pins, and one is sprung outward. This outer pin can be bent out to provide some spring tension and hold the jacks in place while the front panel is installed.

Insert the jacks into the PCB and re-install the front panel to keep the jacks aligned during soldering. Again, secure the front panel in your PCB holder and affix the hex nuts to hold it flat.

With the panel fastened, there may be a small (~1mm) gap between the jack body and the PCB. This is fine! It is more important that the jacks sit **flush against the front panel** so that the strain of plugging and unplugging cables is taken up by the panel rather than the solder joints.
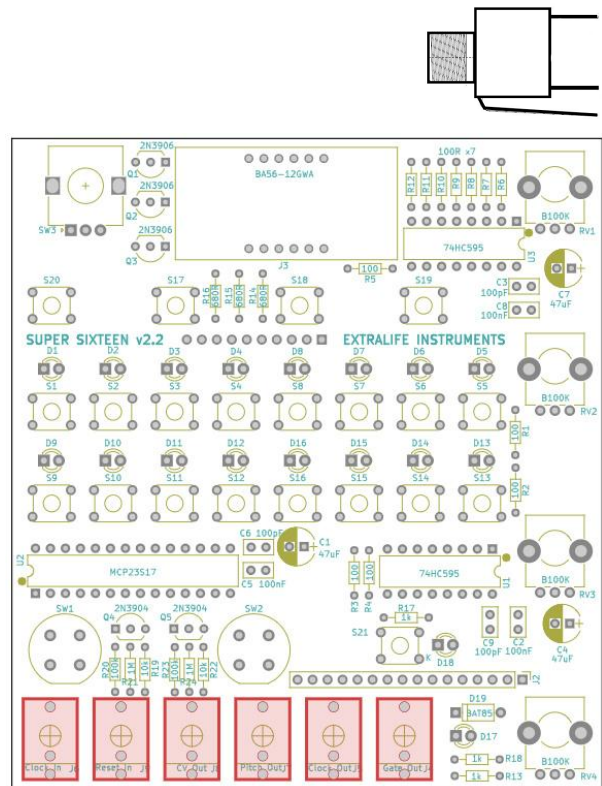
1. Solder the six **WQP518MA** 3.5mm jacks *(J4, J5, J6, J7, J8, J9)*

2.7 - Pushbuttons

The DR640 buttons require careful installation. Make sure to align the **flat side** of the button with the flat side on the PCB silkscreen.

Insert the buttons into their places, then reinstall the front panel and flip over as before.

The buttons will fall down and rest in the front panel cutouts. You can either **tape** the buttons down, or **solder one leg** in place, then with your other hand, **push the button in to rest flat** on the PCB while heating that leg with the soldering iron. Hold it in place while letting the solder cool, and then solder the other 3 legs.

1. Install the two DR640F2 LFS buttons *SW1, SW2*
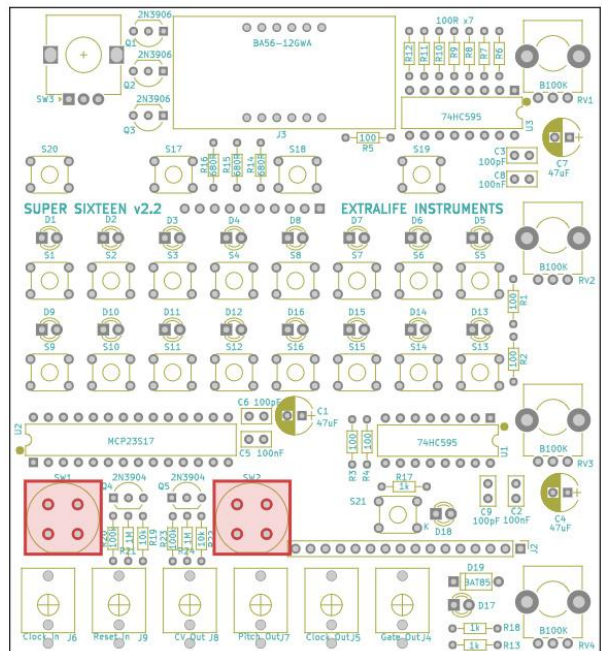
2.8 Electrolytic Capacitors

The electrolytic capacitors on the control board must be **bent sideways to lay flat** against the PCB in order to fit in the space underneath the front panel (see photo). **Bend the leads before inserting them in the PCB or soldering**, as it will not be possible to do so afterward! There should be enough just space between the potentiometers for the capacitors to lay flat on their side. Make sure to observe the correct polarity and match the stripe on the capacitor to the white semicircle on the PCB.

1. Install the three **47uF** capacitors
   C1, C4, C7
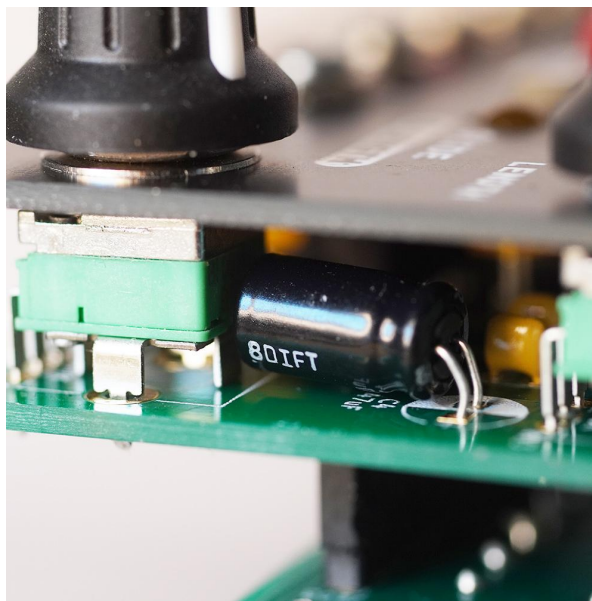
2.9 - Seven Segment Display

The seven segment display is easy enough to install - just make sure you orient it right-side up! It's in the correct position with the decimal points near toward the center of the PCB.

Insert the display into its place, then re-install the front panel as before, and flip the boards over. Let the display fall slightly to sit **flat against the panel** and solder it in place. Be sure that the display doesn't fall partway into the cutout and end up at an odd angle.

1. Install the BA56-12GWA 3-digit seven-segment display
   J1
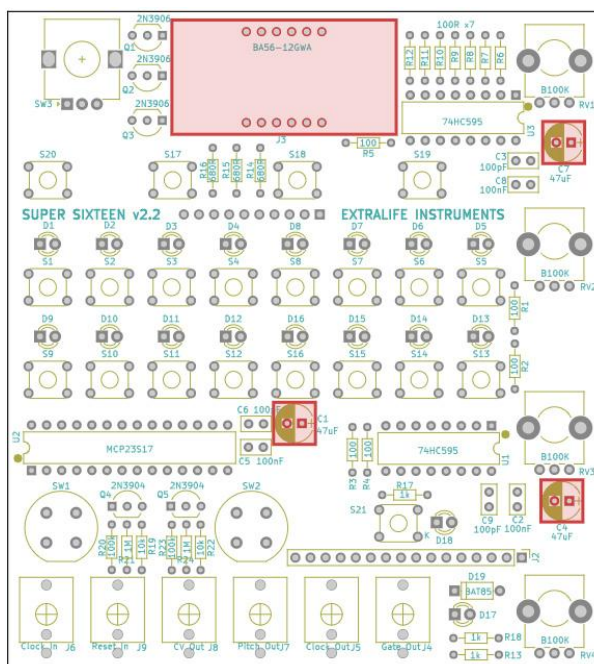
This diagram shows the location of the display and the electrolytic capacitors

2.10 - LEDs

Installing the LEDs should be fairly straightforward if the panel is mounted properly. You must be sure to orient all of the LEDs correctly, by placing the **short leg of the LED in the square pad/hole on the PCB.**

1. Insert the two **5mm LEDs** near the glide button and gate out jack.
   *D17, D18*

2. Insert the sixteen **3mm LEDs** near the switches.
    D1, D2, D3 ... D16

3. Make sure the **hex standoff** is installed near the encoder. This will keep the panel at the correct height from the PCB.

4. **Cover the Gate LED and Glide LED** in the front panel with **masking tape** or painter's tape. This will keep the LEDs from falling through the panel and ending up too tall. You can leave a little slack in the tape to enable the LED to sit slightly proud of the panel.

5. Now, install the front panel. Install the hex nuts as necessary to keep it in place, or carefully insert into your PCB holder.

6. **Flip the board over** and seat the LEDs into the cutouts in the front panel. Grab each LED's legs and wiggle it until it drops down into the cutout. The panel should hold the 3mm leds almost flush with the front, and the tape will do the same for the 5mm leds.

7. **OPTIONAL:** Look at the front of the control panel. If the 3mm LEDs stick too far out when seated into the panel (some LED manufacturers may have different size tolerances!), use painter's tape to cover all the 3mm LED holes to keep them at the right height.

8. Double-check that the LEDs are installed in the **correct orientation**, with the short legs in the square holes on the PCB. Every LED should be oriented in the same direction.

9. Solder all of the LEDs. (*D1, D2, D3 ... D18)*

10. Remove the masking tape and flip the assembly over to inspecti t. The LEDs should now sit just proud of the front panel. If one or more are misaligned, use the soldering iron and pliers to adjust their positions now *before* clipping the component leads.
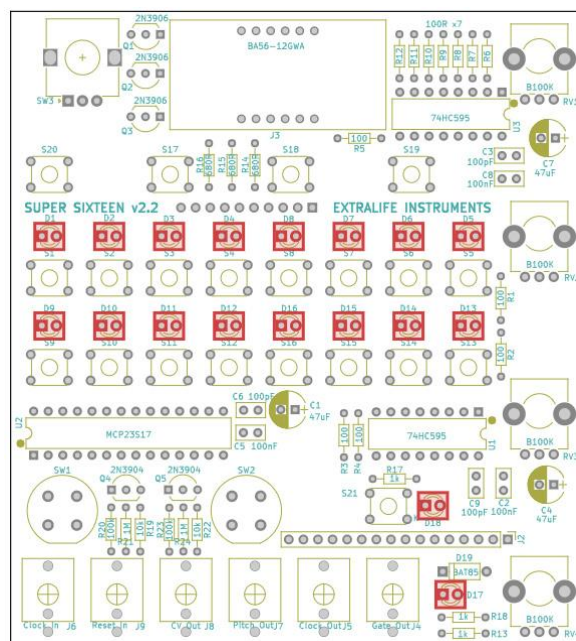
Front panel assembly

3.1 - Inspection & cleanup

Congratulations! You've finished the soldering and have earned a break. Drink some tea, take a nap, etc, because there's a little more work to do and it's not a good idea to rush through it.

When you're refreshed and ready, take this chance to perform a thorough **visual inspection** of both PCBs. Use bright light and magnification to inspect all of the solder joints, and use a felt-tip marker to mark which ones you think need extra attention (there are always a few!). Apply some flux, use more solder, reflow, or use desoldering braid as needed to clean up the joints.

When you are satisfied with your soldering, clean up any **flux residue** from both PCBs using an old toothbrush and some isopropyl alcohol. Blot the boards dry with a paper towel and let them sit for 15-20 minutes to dry fully.

3.2 - Electrical and functional tests

Before applying any power to the module, you should first check for short circuits. Use a **multimeter** in **continuity mode with an audible buzzer.**

1. On the **CPU board,** test for any shorts between the center pins of the **power connector** and the outer pins of the power connector (between +12v / GND, and -12V / GND).

2. On the **CPU board,** test for shorts between any of the legs of the larger **LM7805 voltage regulator** (between +5V/GND, +12V/+5V, and +12V/GND).

3. On the **Control board,** test for shorts between the **outer two** legs of any **potentiometer**, e.g. **RV1**. (between +5V/GND). With the knob turned all the way left or right, you will find a short between the middle leg of the potentiometer and one outer leg - this is normal.

Once you are satisfied, attach the 2nd **hex standoff** to one of the PCBs by inserting a screw through one of the mounting holes near the middle of each PCB, and threading on the hex standoff on the underside of the board. **Mate the two boards together** using the header pins, and insert a screw into the other side of the standoff. **Do not overtighten!** You can flex or crack the board if you are not careful.

Now, at last, you can power up the board by connecting it to a **eurorack power supply**, being careful to observe the **polarity** of the power connector. You should see the display light up and the LEDs begin blinking. Check that all of the knobs and buttons are working!

3.2 - Button caps

Disconnect the power supply, and lightly fit the front panel on the control board - do not install the hex nuts or screws just yet as you may need to remove it again soon.

Install the four **large button caps** by sliding them through the front panel and onto the square plungers of the four topmost tactile switches. Rotate the cap until it seats onto the switch. These larger caps are somewhat difficult to install and may require some force. Having the front panel in place will help you keep them straight while you push them on. The cap should "**click**" onto the switch and sit nearly flush with the front panel. Once seated, the switch should operate easily and "**click**" with each press. If the button feels squishy or stuck, remove the front panel, and gently pry the button cap off the switch by inserting a **small flat-bladed screwdriver under the cap** and twisting it until the cap slides off. Do not force the cap off by pulling at an angle, as this may damage the switch. You may be able to install a stuck cap more easily with the front panel removed, but be very careful to line it up perfectly straight before pushing it on.

Install the seventeen **small button caps** in the same way. These caps will slide on more easily than the others, and it's easiest to do this with the panel installed. They will "click" on **once** when pressed, and then **click again** when pressed with greater force. After the second click they will sit nearly flush with the front panel. You may wish to use a flat tool such as the butt end of a screwdriver, pen, or marker to push the caps on rather than using your fingers. Try to avoid putting too much force on the components on the rear PCB - brace the assembly against your hand rather than a tabletop if possible.

3.3 - Hex nuts

Once the button caps are installed, place a flat washer over each of the four potentiometers. Then install the four **10mm** hex nuts on the potentiometers. It is not necessary to install a nut on the encoder. Instead, install the **black screw** (or metal screw if desired) in the hole near the encoder and tighten it on the standoff.

Install the six **8mm** hex nuts on each of the 3.5mm jacks near the bottom of the panel. Use a socket rather than pliers to tighten them to avoid scratching the panel.

3.4 - Knobs

Finally, install the knobs on the potentiometers and encoder by aligning the flat side of the shaft with the flat in the knob body, and pushing it on until it is nearly flush with the front panel. The **four knobs** with an **indicator line** go on the potentiometers and the **one knob** without a line goes on the encoder.

Congratulations! You've finished building the Super Sixteen. Practice and enjoy!