Building the Zen Hemi

Useful tools and supplies:
a small rat tail file
silicone rubber caulk
epoxy
masking tape
solder and a soldering iron
sandpaper
stain
varnish
a Phillips head screwdriver
a wire stripper/cutter
marker

I. The shell
I've attempted to remove the sharp burrs from the holes through the shell, but this is fine work and you should use the rat tail file or some sandpaper with a strong backing (like part of a belt sander belt) to get rid of the last roughness and make sure the holes are smooth and burr free to your satisfaction. Resist the temptation to sweep around the hole with your finger in case there are metal splinters at first. The shell is stainless steel which should give you a very durable instrument, but it is a difficult material to work with so patience is a virtue.

After getting the holes in shape, you can leave it as it (it is stainless) is or clean it and paint it (get a good primer and then you can use spray paint) or put a swirl finish on it like this (https://www.youtube.com/watch?v=IxAXs76Ut68). I've done the swirl using a single grade of sanding disk and it works pretty well . Or you can polish the stainless steel to a mirror finish (I have not done this, but it might be fun) per: https://www.youtube.com/watch?v=GTJmlXSCD0A) . Because of the optical sensors which don't like paint, it will be hard to refinish the shell after assembly so become happy with it now.

When you're done painting or polishing the shell, thoroughly clean the inside with dishwasher soap and water and then dry it so that there will be good adhesion with the silicone caulk to be used later.

II. The wooden base plate
Sand and stain or color the base plate to your liking. I like it natural, but I have also consider using dilute acrylic colors and then covering them with varnish. Sand between the varnish layers with 120 grit for a smooth finish. There's no need to finish the wood that faces into the shell and you may want to leave that unsealed for humidity equalization.

III. The electronics
The small square circuit boards are the optical sensors and you will need to solder the pins on the back of these boards (the pins face away from the side opposite the side with the circuitry circuitry and upward from the side with the lettering).

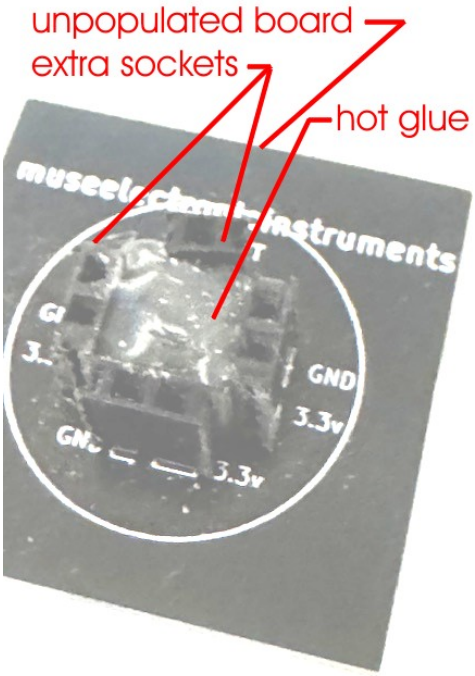
this side faces out of
the shell through a hole

this side faces the
interior of the shell

this side has a
photodetector

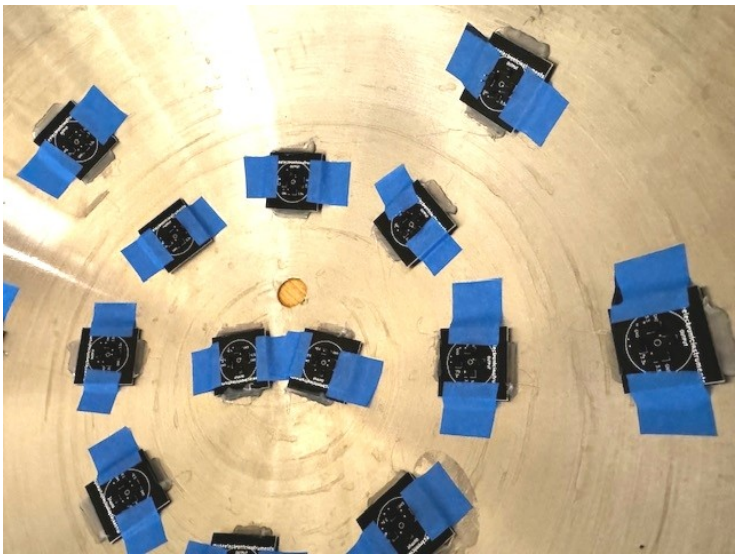
the pins extend out from this side
and are soldered from the other
side

It's hard to keep the pins all lined up so I have provided a unpopulated circuit board and some sockets that you use to make a jig if you would like. To do this, put the sockets in the unpopulated board and then put pins in one of the optical sensors and plug them together (unsoldered) which should get everything lined up. Then, holding this together, solder the sockets in place. If things still seem lined up after that, it may make sense to fill the gap between the sockets with hot glue or silicone rubber to keep them aligned. Now when you are assembling the other optical sensors you can plug the pins into the sockets and then insert the board on top of those pins with everything will be held and oriented for easy soldering. Make sure you solder the pins on the correct side of the unpopulated board so that they work with the proper orientation of the photo boards with the pins extending away from the side opposite the components.



(a) Solder pins in all 40 of these optical sensors.

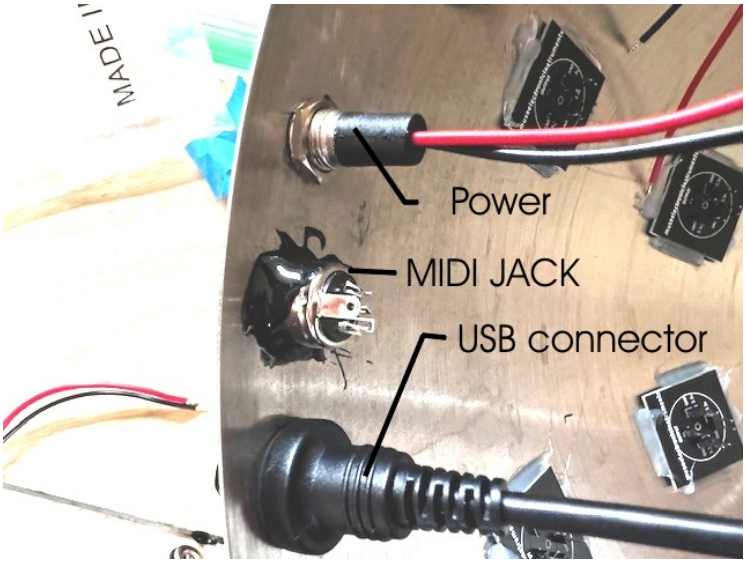
(b) Using tape, tape each optical sensor to be aligned with a corresponding one the holes (any optical sensor works with any hole) in the shell centered by looking at the white ring on the optical sensor side. It's useful to have them all facing so that the output pin is furthest from the center of the shell. (It's not necessary but it will help keep things straight when the wiring starts). Tape only on two opposed sides of each optical sensor board (you're leaving the other sides open for gluing). Turn the shell over and check and reposition any optical sensors that are not aligned. It should look something like this. Note that one of the holes is open which will hold a pushbutton to make sure you don't put an optical sensor there.



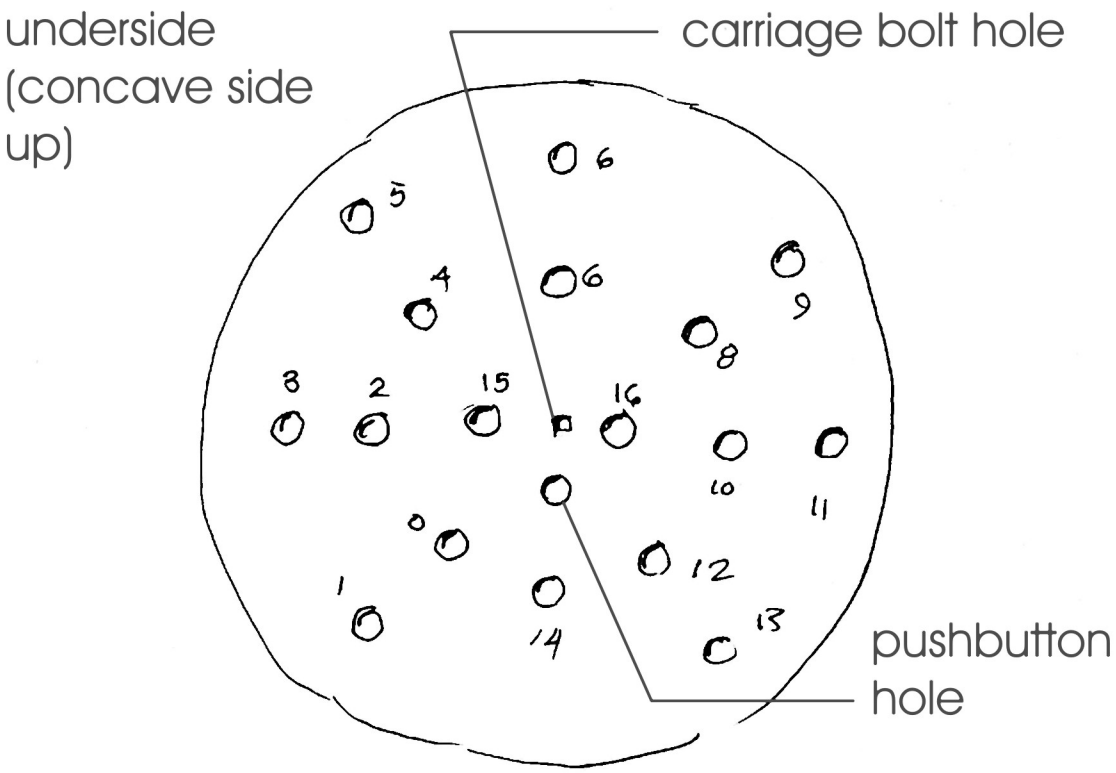
(c) Lay bead of silicon rubber on the exposed edges of each board joining that edge to the metal of the shell. Let everything cure and then carefully remove the tape and lay a bead of silicone rubber down on the remaining exposed edges so that all four edges are firmly attached to the inner surface of the shell

(d) epoxy the MIDI DIN Jack to the center most hole applying epoxy to the periphery as shown only on the inside of the shell. For this purpose, it is best if you apply tape over the entire outside of the jack to press the jack in the place and prevent epoxy from passing out of the hole. Keep the epoxy away from the metal connectors to which you will solder.

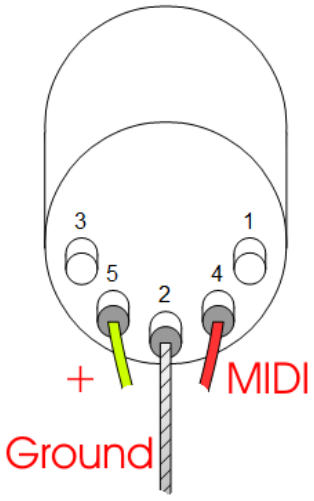
(e) Install the power jack and USB connector. Cut two of the male-female jumper wires (roughly in half) and slip a length of heat shrink tubing over each wire with a female connector. Then solder the wire with the female connector to a corresponding wire of the power jack (see if you can use colors that roughly match red and black to keep from getting confused). Red is positive voltage and black is negative voltage or ground (GND). After soldering the wires, shrink the heat shrink tubing over the exposed joint using the soldering iron or a hot air gun. NOTE: DO NOT USE ANY OF THE FEMALE-FEMALE JUMPER CABLES AT THIS TIME.



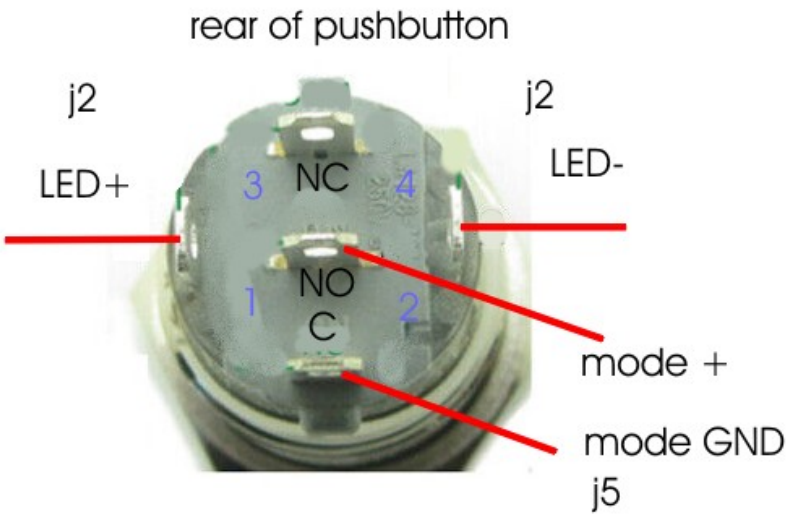
(f) use a marker to mark the shell next to each of the optical sensors as follows:



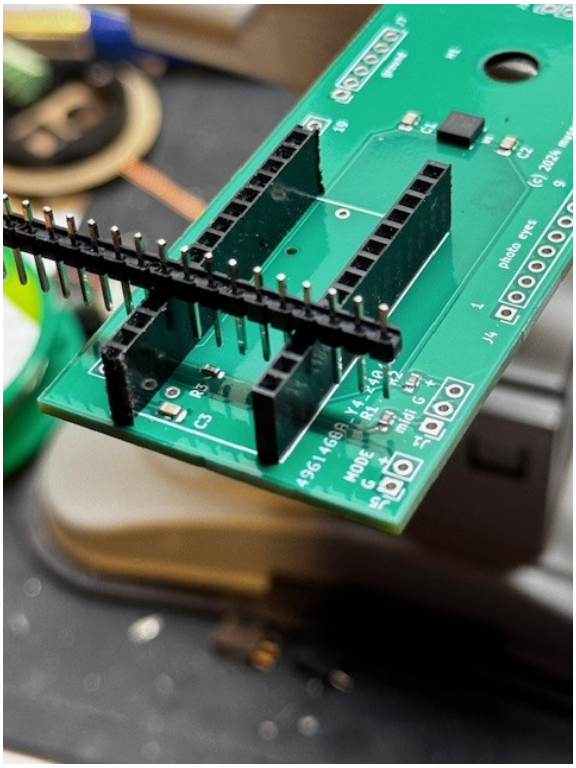
(g) Cut three of the male-female jumper wires very close to the male jack and solder them to the pins of the MIDI DIN jack. Use the following diagram when you ultimately connect this to the printed circuit board.

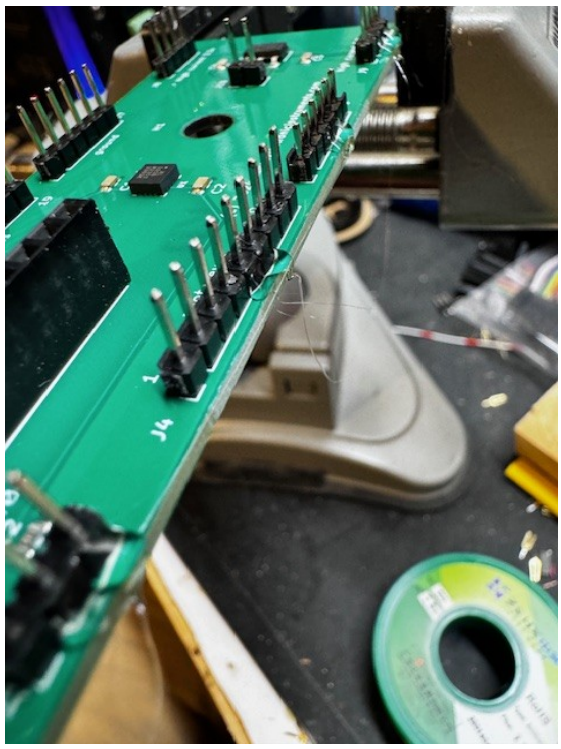


(h) Install the pushbutton in the open pushbutton hole and cut additional male-female jumper wires close to the male jack and solder the female connector wires to the pushbutton pins as follows. Use this diagram later when you are connecting the pushbutton to the printed circuit board.



(i) Solder the pins and sockets to the main printed circuit board. Start with the sockets and you can use one of the pins strips to line things up properly. Next solder the pins down. The pin strips will snap, if you are careful, to the right length. The alignment of these pins is not critical, but it's nice to keep things neat.



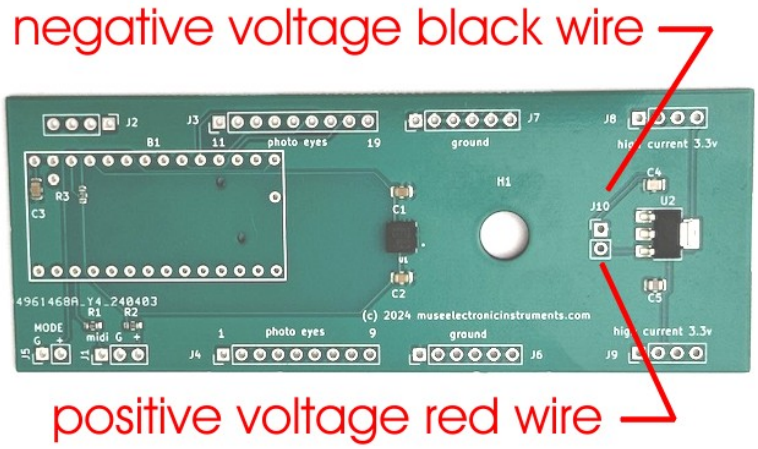


(j) Solder the pins on the Teensy (extending away from the side opposite side with the components) using the socket to line the pins up. For the moment, put away the Teensy for safekeeping in its static resistant bag

(k) Place the carriage bolt through the top square hole in the shell and tighten a nut to hold it in place. The carriage bolt will not be held tightly because of the thinness of the shell which is okay, but if you'd like, place some silicone rubber around the nut and let it cure. Tighten and second nut onto carriage bolt shaft about 2 inches from the shell and then slip on a nylon washer on top of that and then place the printed circuit board on top of that with the component side up then add another nylon washer and loosely tighten another nut on top of that washer making sure the board can still swivel.

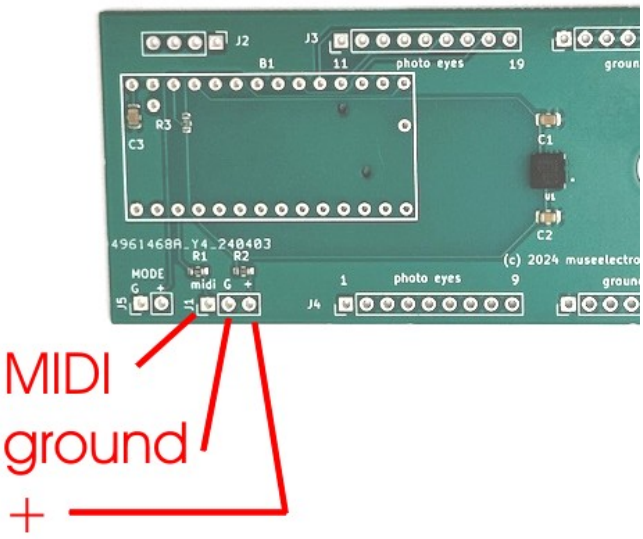
(l) Swivel the board around until it it is positioned so that the Teensy may to connect with the USB connector (you can put the Teensy and temporarily to see how this works). You can now tighten the nuts against the board.

(m) Connect the wires from the power jack to the pins labeled J10 with the red wire connected to the lower pin surrounded by a box having a circular pad and the black wire connected to the upper pin having a square pad. I am sorry this is not more clearly labeled but double check. <u>This is about the only thing you can get really wrong so check one more time and look at the figure below.</u> Note that the pictures below don't show the pins that you have previously soldered onto the board. You should be able to just plug in the jumper wires to those pins.

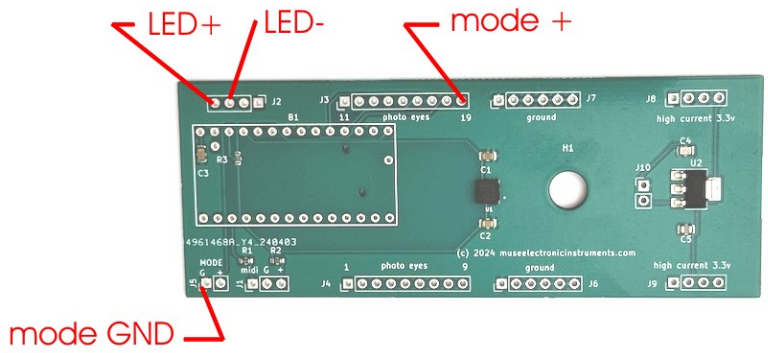


a note on the jumper wires. I think I found a pretty good supplier, but when you place a jumper on one of the pins if it feels it all loose you will want to tighten it up. This can be done by carefully removing the black shroud over the female connector. You may need a thin blade slightly pull up on a tab on this shroud. Practice with the male connector shrouds which will not be used. After the shroud is removed, it will expose the metal of the conductor and you can use a pointed object like a nail and press in on a metal finger of the connector to make it tighter. Do this a bit at a time and then try it out. You can then put the plastic shroud back on.

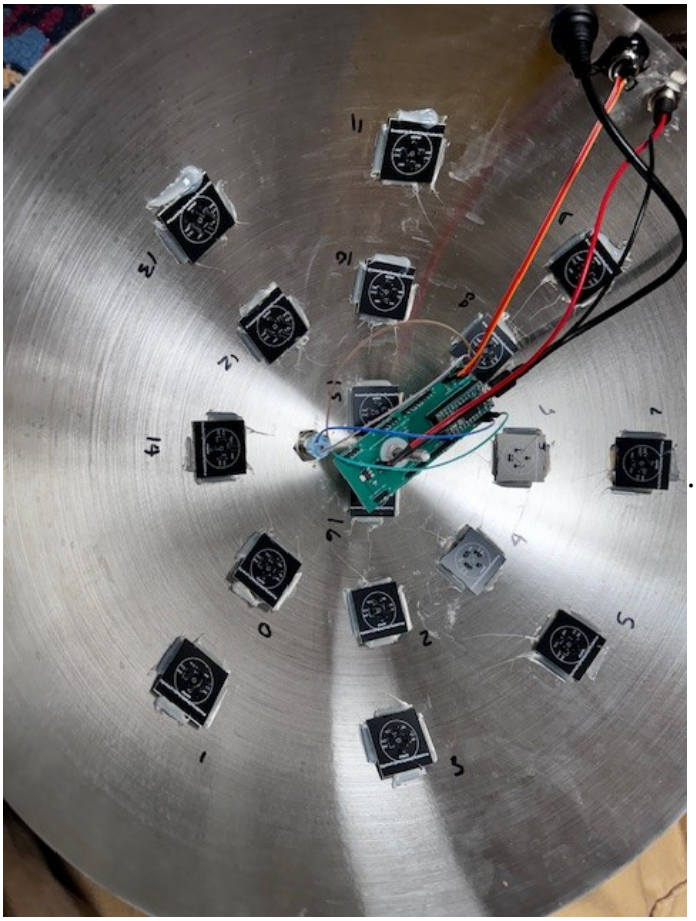
(n) Connect the wires from the MIDI jack as follows:



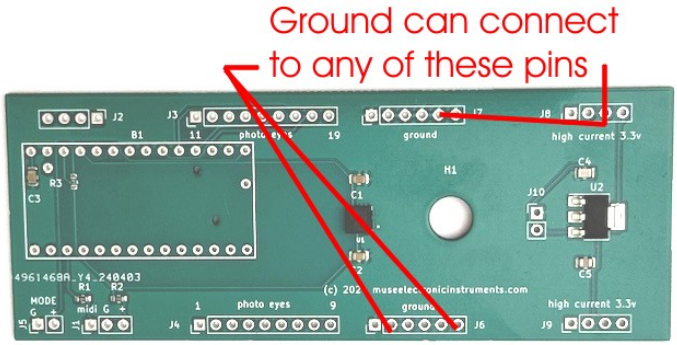
(o) Connect the pushbutton wires as follows:

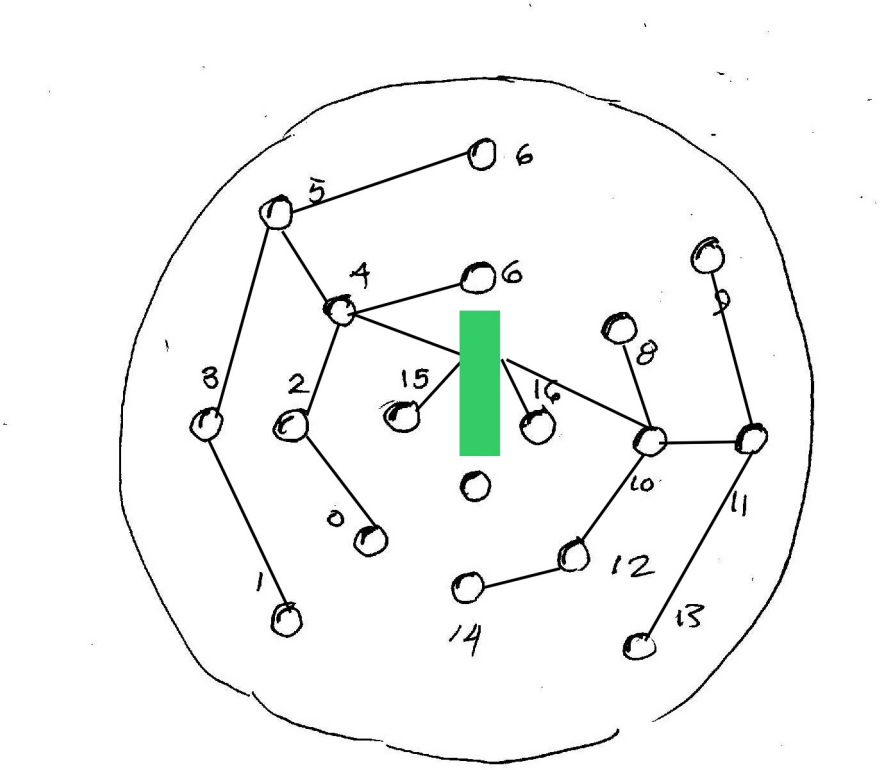


When you’re done it should look like this

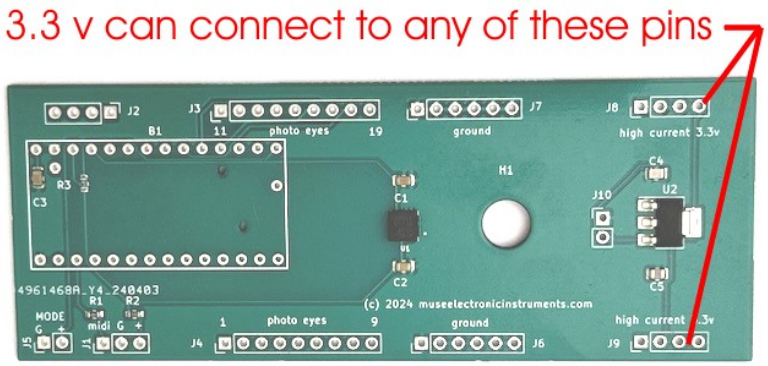


(p) Connect black jumpers from any of the ground pins and daisy chain the connections until you have connected all of the ground pins of all of the optical sensors. The exact order doesn't matter but here's a decent pattern. Triple check that these wires only connect to the ground pins labeled GND. Each optical sensor has multiple ground pins that are all interconnected so you can use any of them when connecting an optical sensor to another point or for making branches.



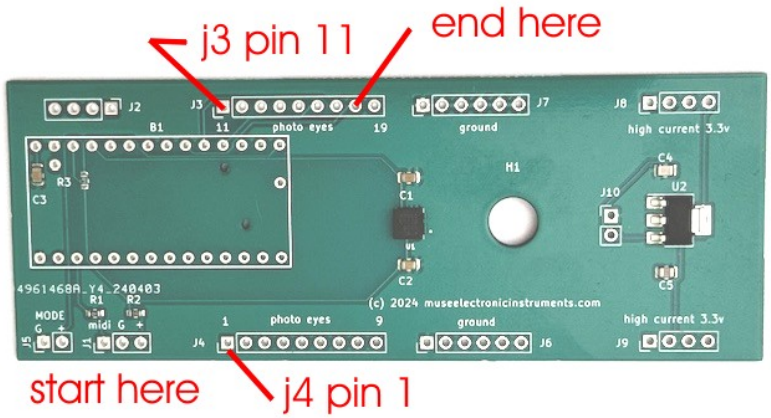


(q) Make similar connections using the red jumpers to connect each optical sensor to a 3.3 V pin on the printed circuit board. Any of the 3.3 V pins are acceptable. You can use the same pattern (it will probably keep you from making mistakes) that you used for the ground connections placing the red connectors next to the black connectors to help you double check visually. It can get quite confusing so be methodical. Double check that red wires only go to 3.3 V pins.



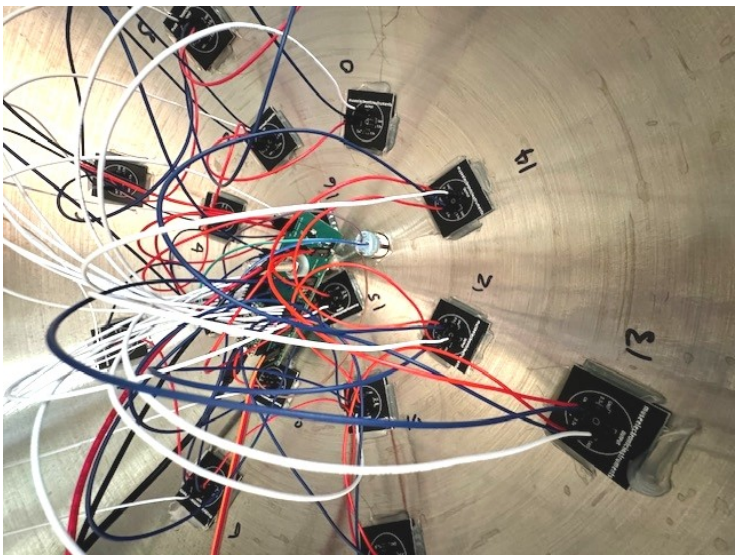
(r) Use the white jumper wires to connect an output from each optical sensor to the pin as on the printed circuit board as follows:

Optical element	Printed circuit board pin
0	1 (j4)
1	2((j4)
2	3 (j4)
3	4 (j4)
4	5 (j4)
5	6 (j4)
6	7 (j4)
7	8 (j4)
8	9 (j4)
9	11 (j3)
10	12 (j3)
11	13(j3)
12	14 (j3)
13	15 (j3)
14	16 (j3)
15	17 (j3)
16	18 (j3)



I

It gets quite complicated quickly so be careful. If you have a voltmeter, you can plug in the wall adapter at this time and check the voltages on each of the optical sensors



IV. Loading the program

You must now install the program for the Zen Hemi program into the Teensy microcomputer. These instructions are for Windows machines but a similar approach should work with Mac hardware and Linux hardware.

(a) Go to https://www.pjrc.com/teensy/td_download.html and follow the instructions for downloading the Arduino software and the Teensyduino add on. You can then then use the Arduino IDE to install the program that came on the disk (also available on the website www.museelectronicinstruments.com) into the teensy. A video that describes this process for the Zen Flute (a different product but using the same microcontroller) is here (https://www.youtube.com/watch?v=wfLB0oTqk0o)

(b) Install the Teensy, plug the USB connector then plug in a USB cable to the socket of the connector outside of the shell. Plug the other end of the USB cable into your computer. Make sure the wall adapter is attached to the power socket and plugged in. Load the program into the Arduino IDE then compile and download the program into the Teensy by selecting the "Sketch" menu and "Verify/Compile" or pressing the circular button in the upper left-hand corner with the right facing arrow. Assuming this compiles and downloads, open the Serial monitor using the "Tools" menu and "Serial Monitor". You should then see printed text indicating a sensing event every time you cover one of the optical sensors with your hand.

You should also see the LED of the pushbutton pulsing.

Assuming everything checks out you can put the bottom panel on to the shell using the connector nut on the carriage bolt that supports the printed circuit board and the countersunk head machine screw. It can be a bit tricky to make this last connection but try to view the bolt and connector nut with both eyes to maintain your stereo vision, or sight downward through the hole in the base plate to line it up with the connector nut. You may need to rotate the bottom panel to find the perfect fit

You should be ready to play.

V. Recommended synthesizers

I am using Ableton with the brushed bells synthesizer sound. Native Instruments offers a free set of synthesized instruments wrapped with Komplete Kontrol. You need to load some other free programs that they have so it's a bit complicated but some of the sounds are really great. I think they offer it for free to entice you into their DAW which I'm guessing is pretty good. You should also be able to use this with a conventional MIDI jack and standalone synthesizer without a computer

Contact me if you have any problems: info@museelectronicinstruments.com