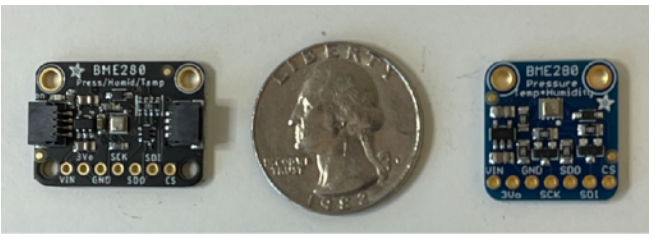
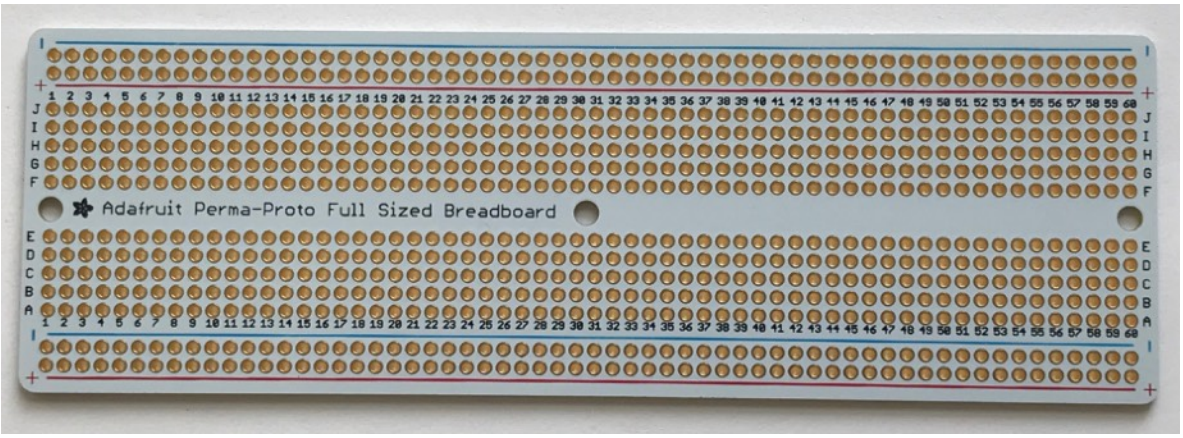
NOTE: These build instructions work for both the configurations of the BME280 (WX) board. That board is no longer available without the connectors.



Parts:

□ Circuit board, prototyping style, "Perma-Proto Full Sized Breadboard"

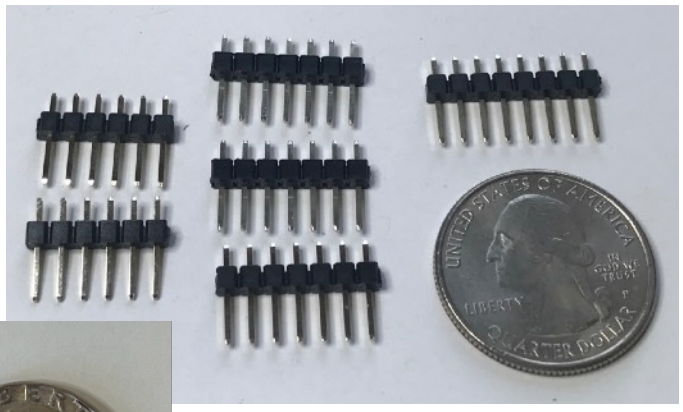


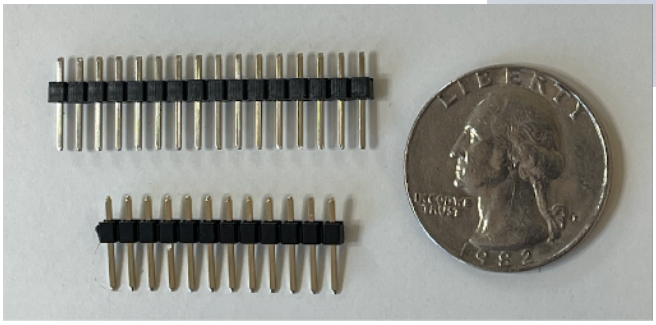
Hookup wire, 24 AWG (American Wire Gauge). (22-26 AWG)

30 cm = 12" each
□ Black jacketed wire
□ Red jacketed wire
□ Yellow jacketed wire
□ Green jacketed wire
□ Blue jacketed wire
□ Violet jacketed wire
□ Grey jacketed wire
□ White jacketed wire

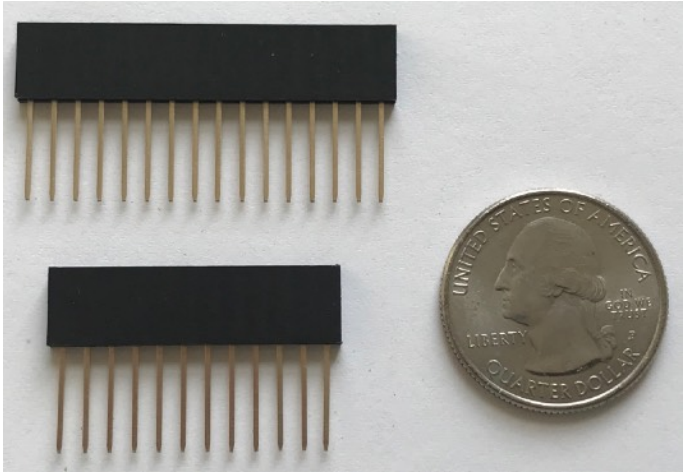
Header pins

- ☐ 16 pins length, 1 piece
- ☐ 12 pins length, 1 piece
- ☐ 8 pins length, 1 piece
- ☐ 7 pins length, 3 pieces
- ☐ 6 pins length, 2 pieces
- ☐ 1 piece each, 16 and12 pins



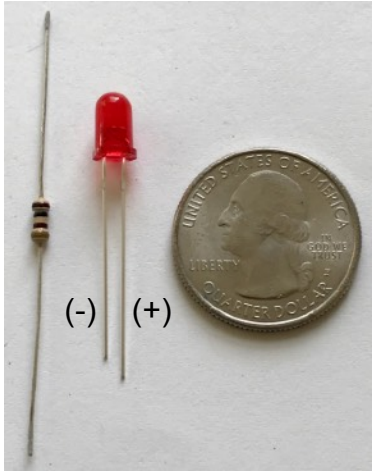


☐ Stacking headers set. 16 and 12 places, one each.



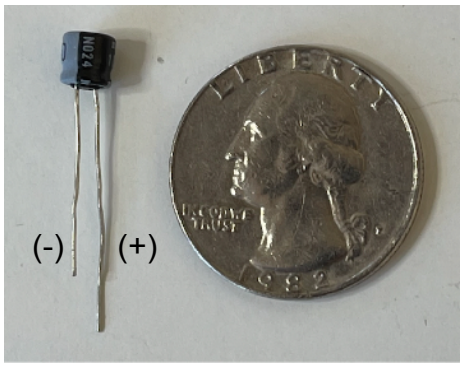
□ 100Ω resistor

□ Light Emitting Diode (LED)

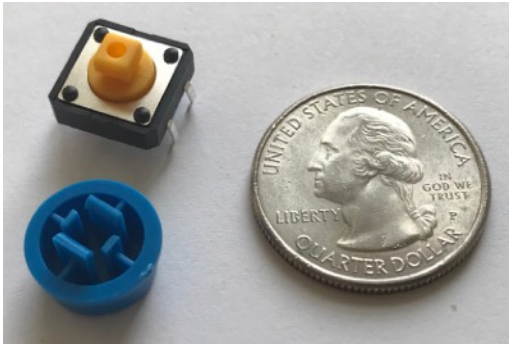


□ Heat shrinkable tubing, any color, 1.5 - 3 mm diameter (1/16-1/8") 15 mm length (5/8"), 1 piece

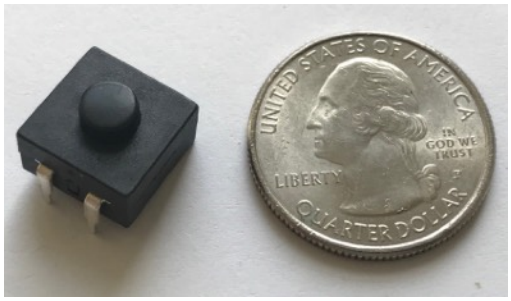
□ 10μF 25V capacitor



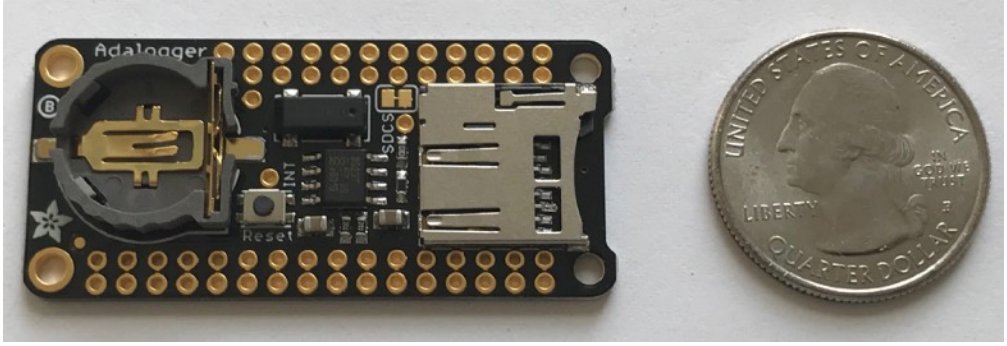
□ Momentary pushbutton switch



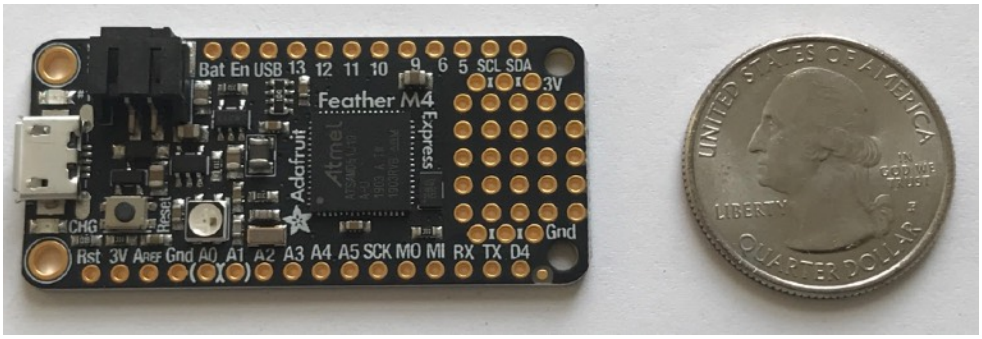
□ Push on, push off switch



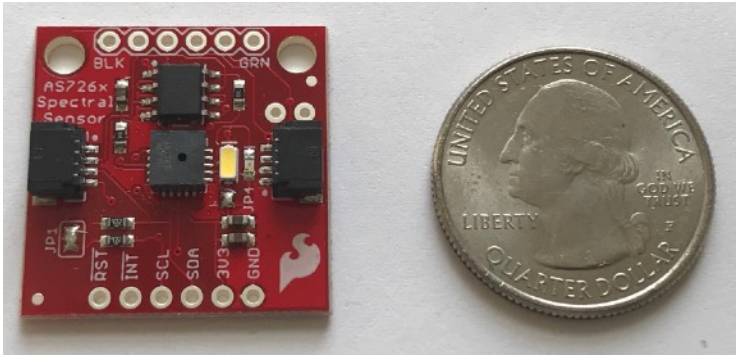
□ Data logging card, Featherwing style. "Adalogger"



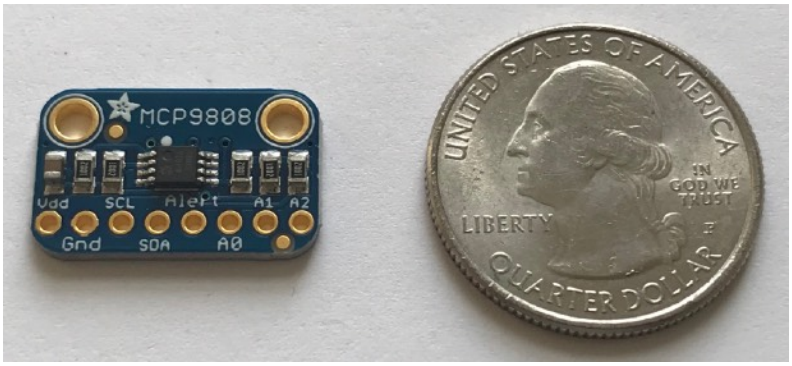
□ Feather M4 Express microprocessor



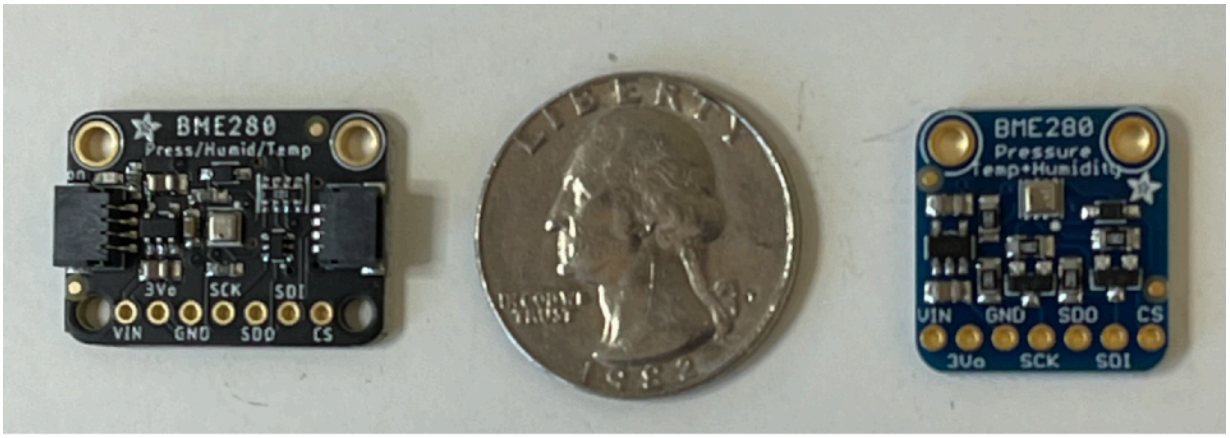
□ Near Infrared spectrum sensor: NIR



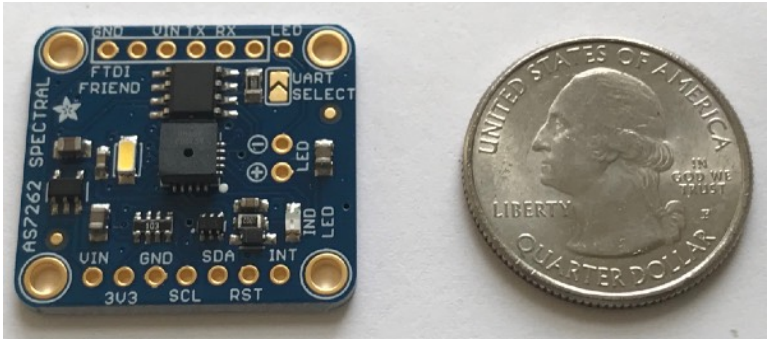
□ Air Temperature sensor: AT



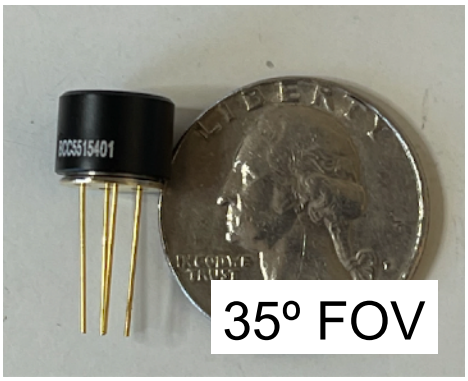
□ Weather sensor, humidity and barometric pressure: WX
Use *either* the newer (Left) or the older version (Right). These instructions work for both versions.

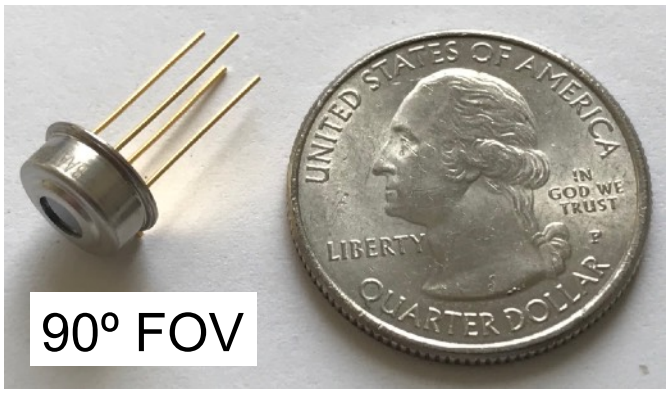


□ Visible spectrum sensor: VIS

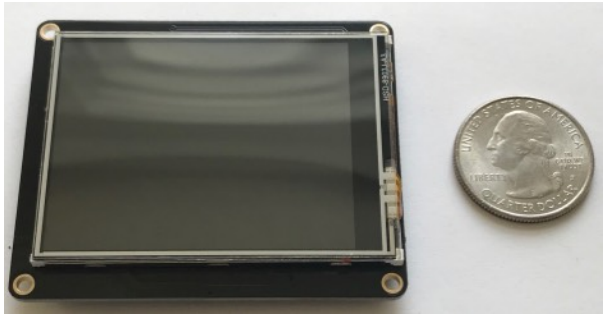


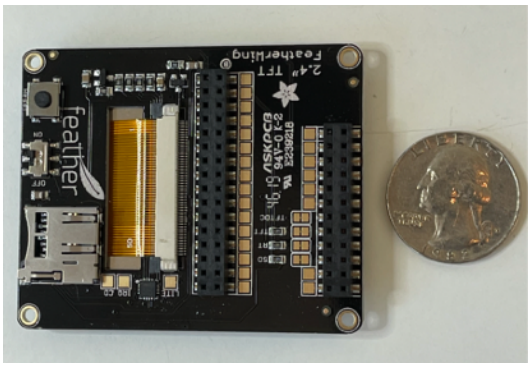
□ Thermal Infrared non-contact surface temperature sensor: TIR. Use *either* the 35º Field of View sensor or the 90º FOV sensor. The 35º FOV sensor is a bit more expensive, but is a better match to the field of view of the optical sensors.





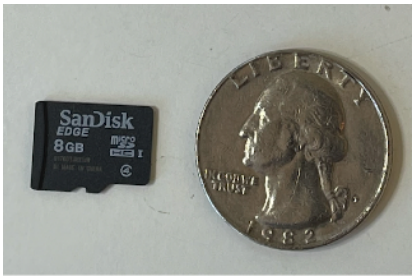
□ Thin Film Transistor touch screen display, Featherwing style. Front and back views.



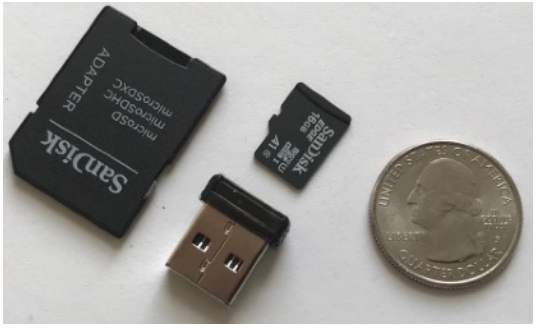


□ CR1220 clock battery

□ Secure Digital microSD memory card



□ microSD card adapter: needed to read out the microSD card data.
Two different kinds of adapters are shown here. SD card slot type, USB A type.



□ Lithium ion battery, larger for handheld use, or smaller for drone use.

□ USB (Universal Serial Bus) cable:
USB A to micro b (left) or USB C to micro b (right). Choose one to match the ports on your computer. Use a data cable, not a power-only cable. If the processor doesn't show up as an external drive on your computer, you may have a power-only cable. Replace it with a data cable, to be able to program the instrument.

Tools and supplies list:

□ Wire cutter

□ Wire stripper -- 26-22 AWG

□ Needle nose pliers

□ Soldering iron, with a soldering iron stand

□ Lead-free solder, SAC305 alloy: Sn (tin) 97%, Ag (silver) 3%, Cu (copper) 0.5%
Leaded solder will work, but choosing the Least Toxic Alternative is good safety practice.

□ Desoldering braid

□ Safety glasses

□ Soldering fume exhauster

□ Full size breadboard, for use as an assembly fixture

□ Ruler.

□ 3D printer, fused filament type, 20 cm cube printing volume.

□ Printer filament: black, white, blue

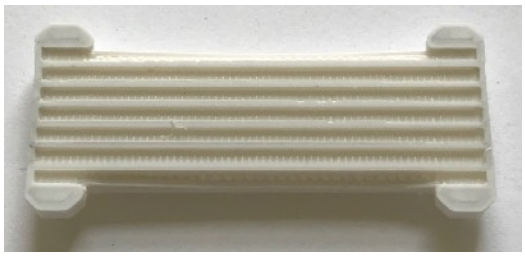
□ Computer: A computer running either Apple Macintosh or Microsoft Windows operating systems. It is likely possible to do this work on a computer running Linux, but these instructions do not cover Linux. So far, it seems not possible to do this work on a Chromebook (as of July 2020).

□ Optional: thin film double stick tape, for mounting the power button

□ Optional: solder sucker: suction desoldering tool

Assembly: (See the full circuit schematic at the end of these instructions.)

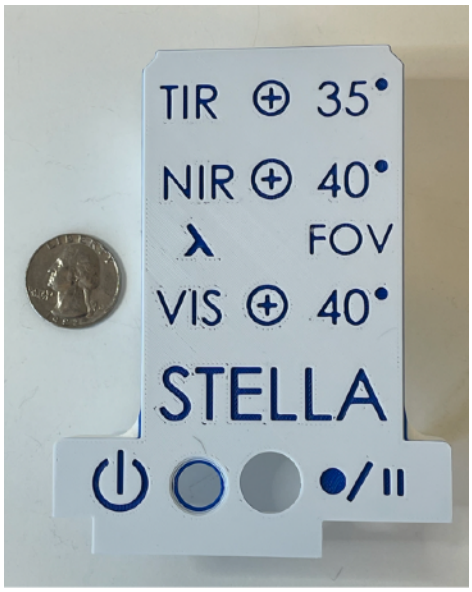
1. Print spacers:
□ Feather microprocessor spacer.



□ Thermal infrared sensor spacer.

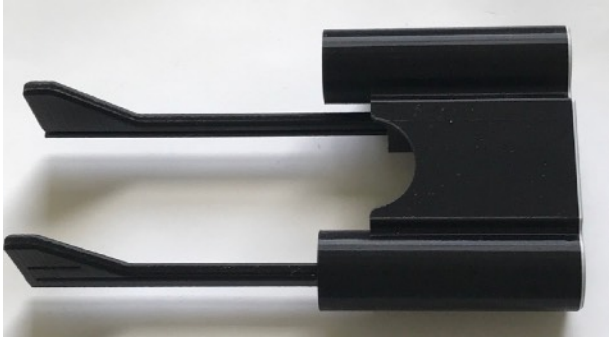
□ Board assembly helper spacer.

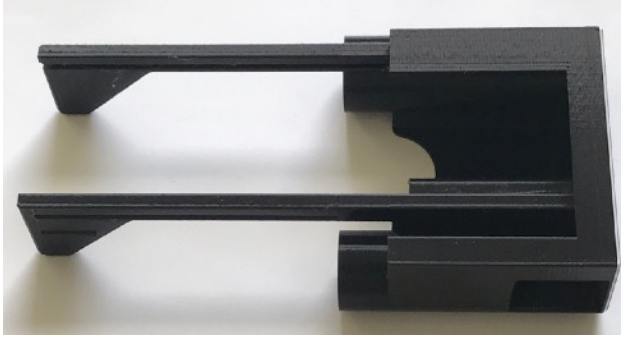
2. Start prints for the housing. Housing parts take a lot of time to print.
□ Housing cover. Choose the 3D file that matches the field of view of the thermal infrared sensor you are using. Change filament color at Z = 0.6 mm and 1.4 mm, to make the text easy to read.



90º FOV cover photo TDB

□ Housing base. Change filament color at Z = 0.6 mm and 1.4 mm, to make the edges pretty, and to show the USB Serial Bus symbol.





end view photos TBD

3. Run wiring.

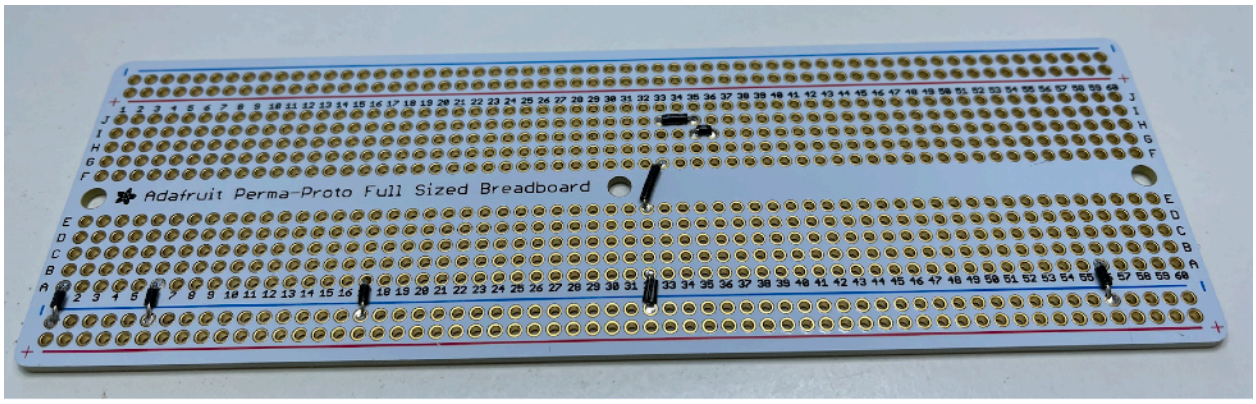
3.1. Ground (black wire):

Front: Connect each to (-) bus below A row.

- ☐ A1
- ☐ A6
- ☐ A17
- ☐ A32
- ☐ A56

Front: Connect point to point.

- ☐ E32 - F33
- ☐ I33 - I35
- ☐ H35 - H36



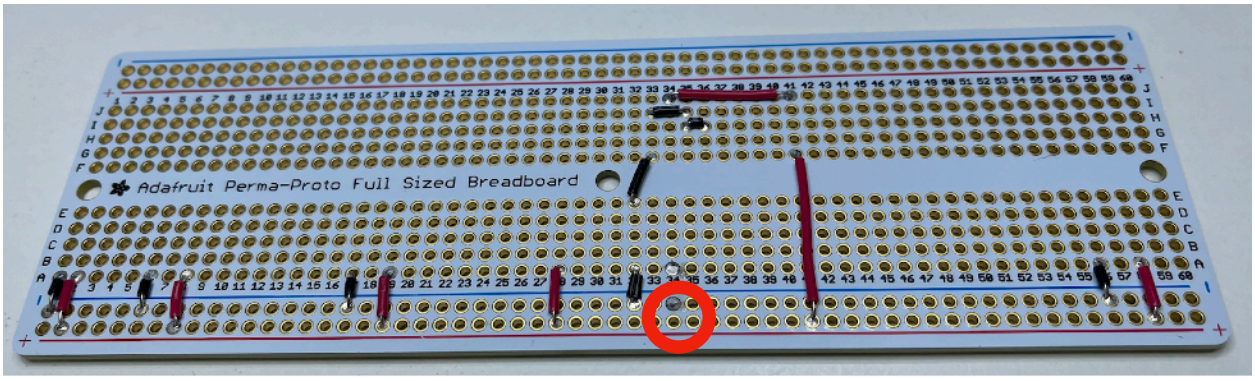
3.2. Power (red wire):

Front: Connect each to (+) bus below A row.

- ☐ A2
- ☐ A8
- ☐ A19
- ☐ A28
- ☐ F41
- ☐ A58

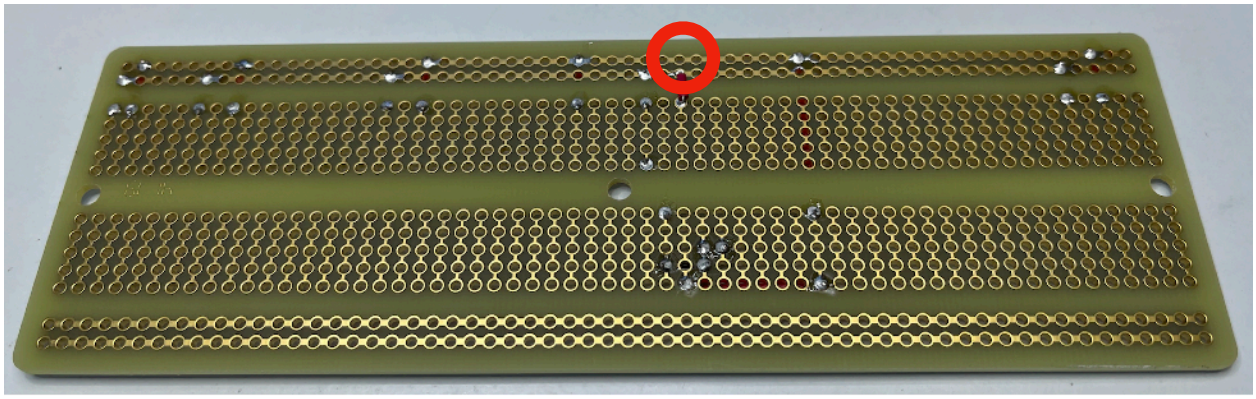
Front: Connect point to point:

- ☐ J34 - J41



Back: Connect each to (+) bus below A row. (Photo is incorrect where circled. Text is correct).

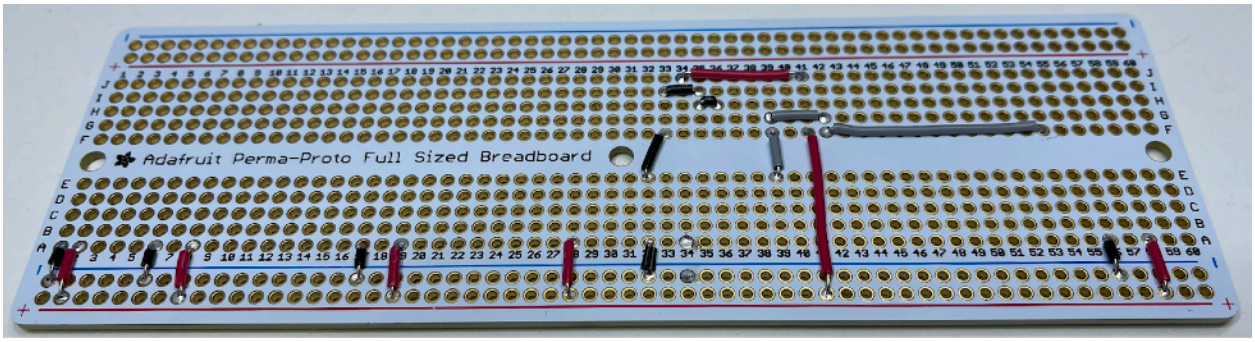
- ☐ A34



3.3. Enable (grey wire):

Front: Connect point to point.

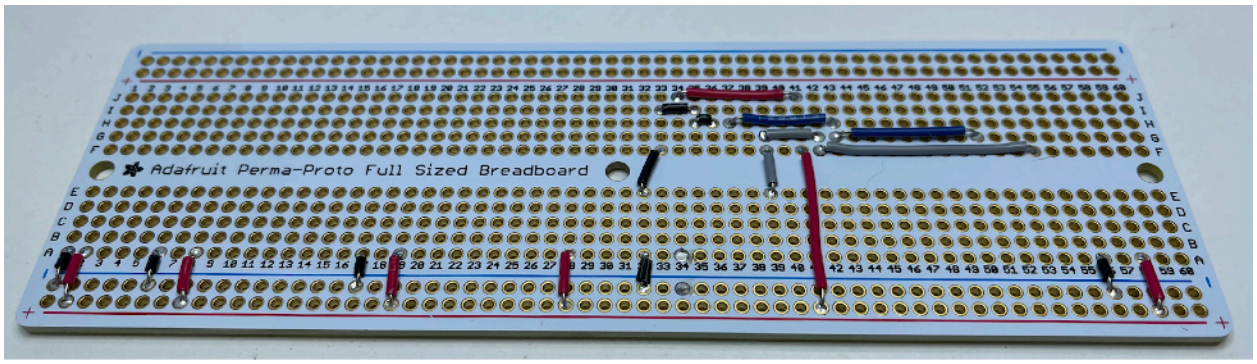
- □ E39 - F39
- □ G39 - G42
- □ F42 - F54

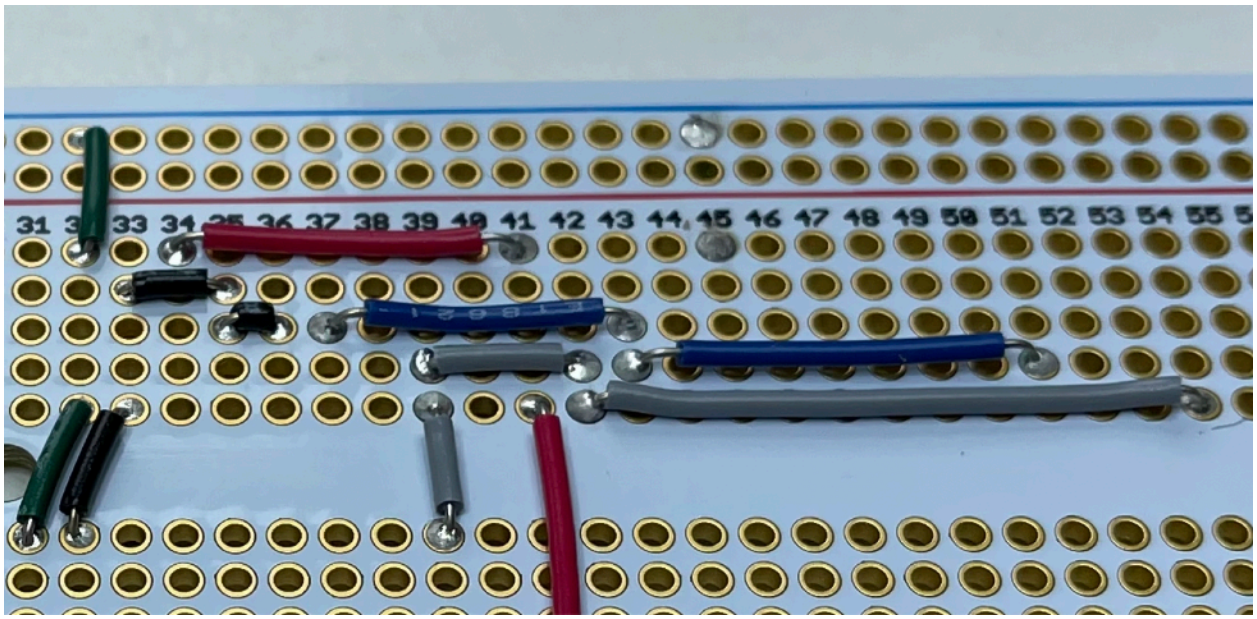


3.4. Pushbutton wiring (blue wire):

Front: Connect point to point.

- □ H37 - H43
- □ G43 - G51





IIC, I²C, I2C = Integrated circuit to Integrated circuit communications.

3.5. SCK (I2C Serial ClocK) (green wire):

Front: Connect each to the (-) bus above the J row.

□ J1

□ J20

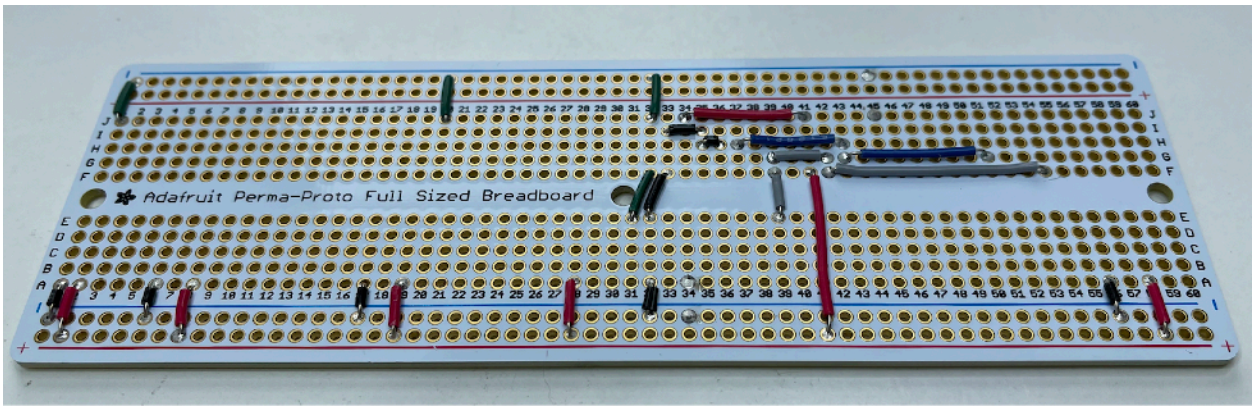
□ J32.

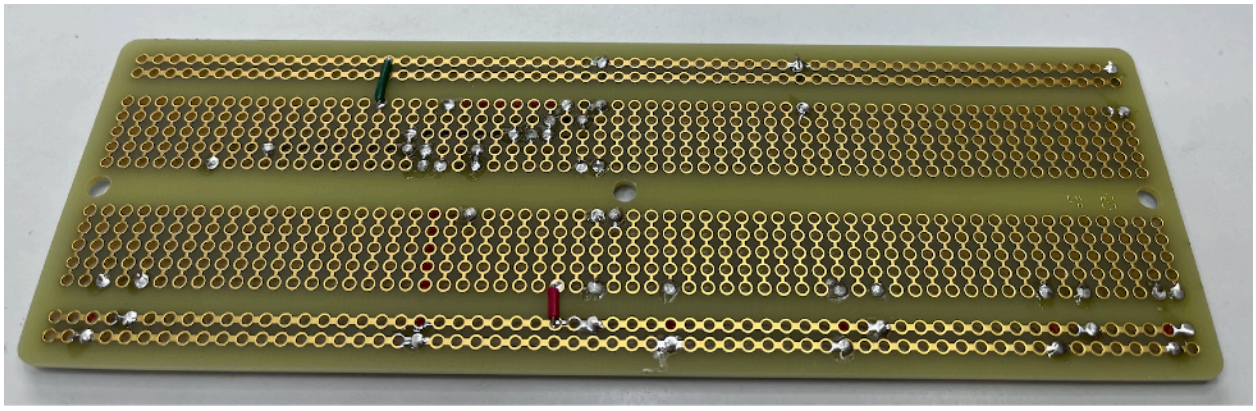
Front: Connect point to point

□ E31 - F32.

Back: Connect to the (-) bus above the J row, on the back of the board.

□ J45





3.6. SDA (I2C Serial Data) (white wire):

Front: Connect each wire to the (+) bus above the J row.

□ J2

□ J21

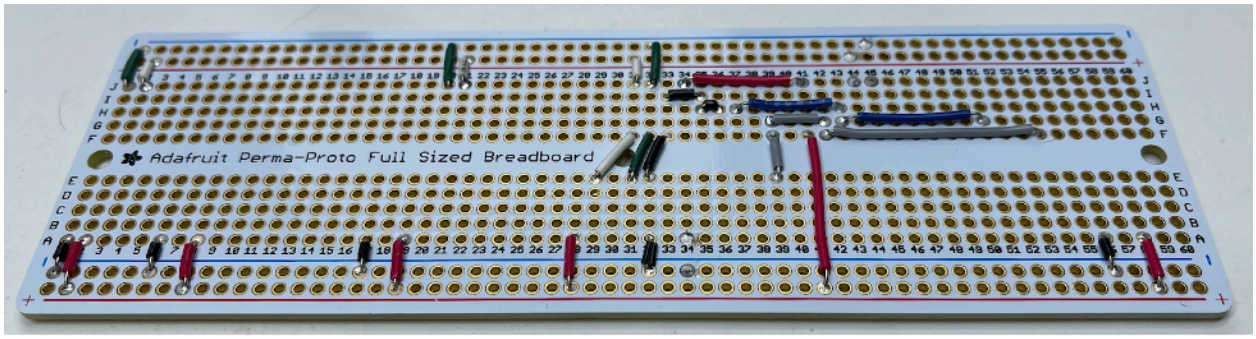
□ J31

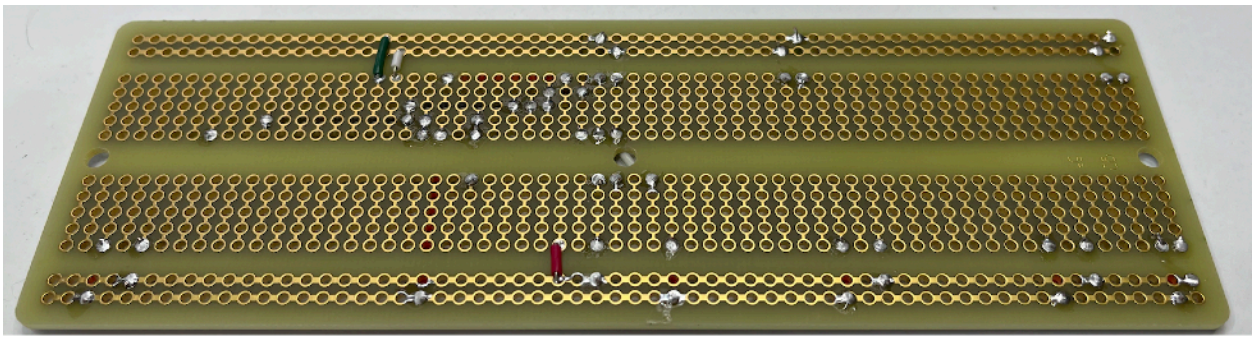
Front: Connect point to point.

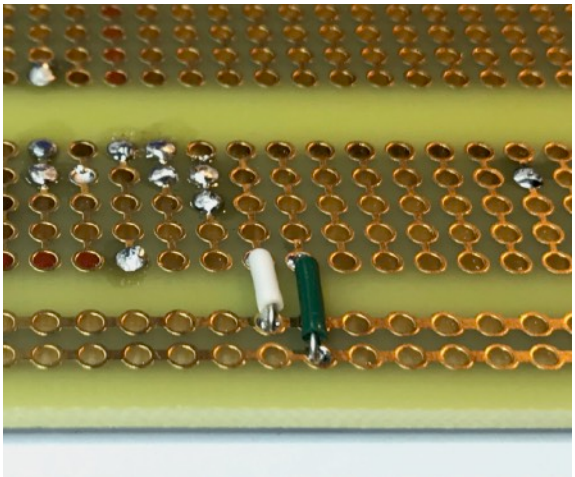
□ E29 - F31.

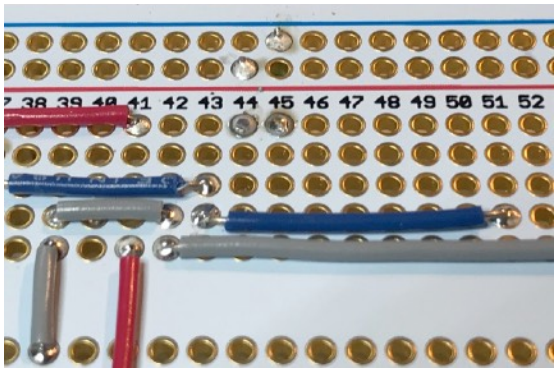
Back: Connect to the (+) bus above the J row, on the back of the board.

□ J44







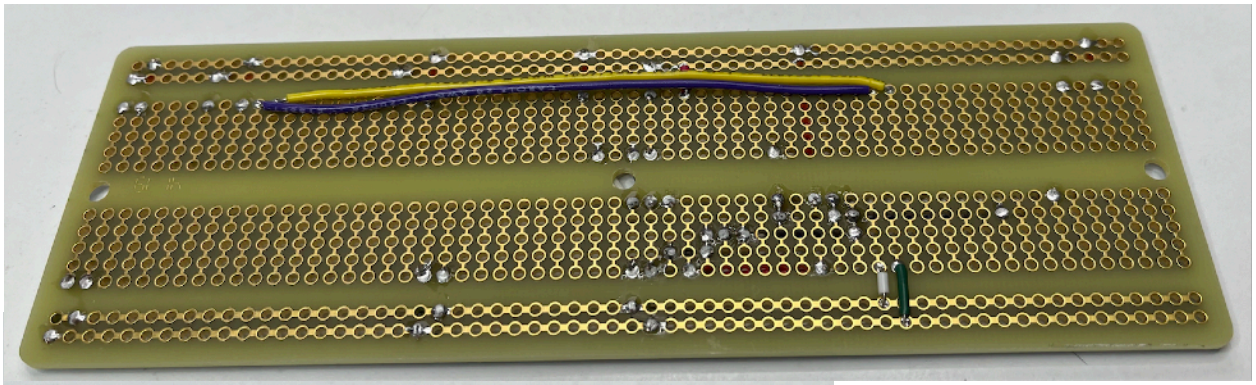


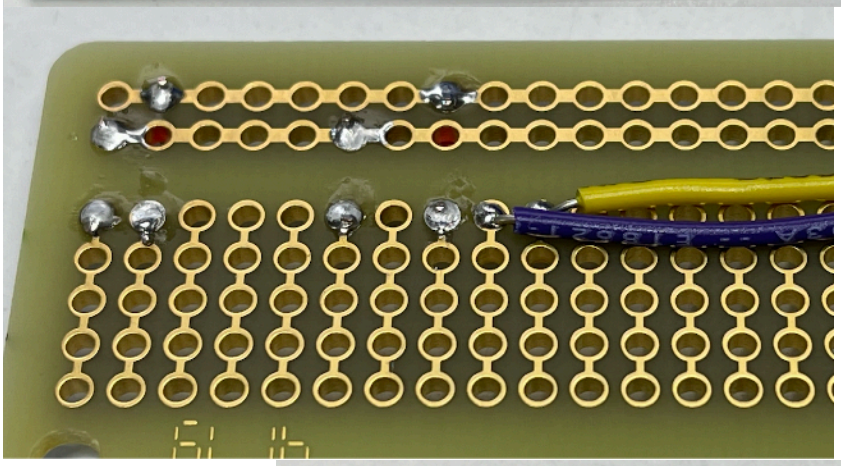
UART = Universal Asynchronous Receiver/Transmitter

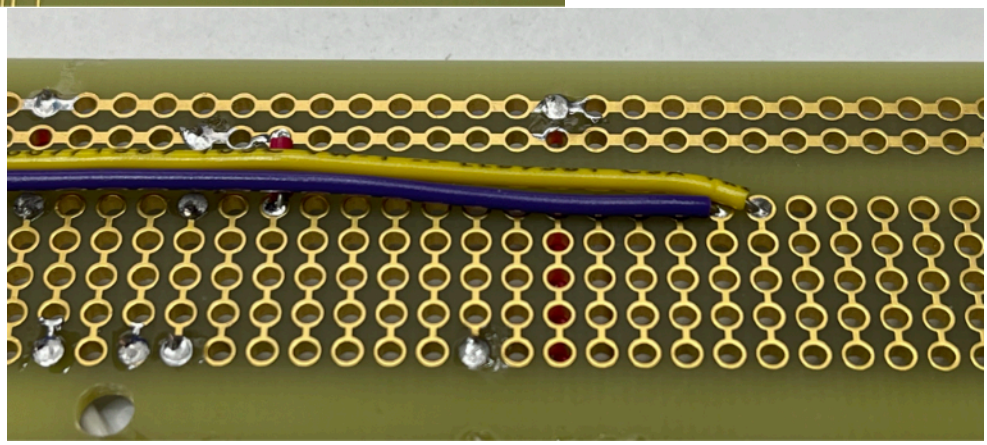
3.7 connect the UART lines between the microcontroller and the NIR sensor.

RX (receive from NIR sensor) (yellow wire):
Back: Connect point to point.
□ A46 - A10

TX (transmit to NIR sensor) (violet wire):
Back: Connect point to point.
□ A45 - A9



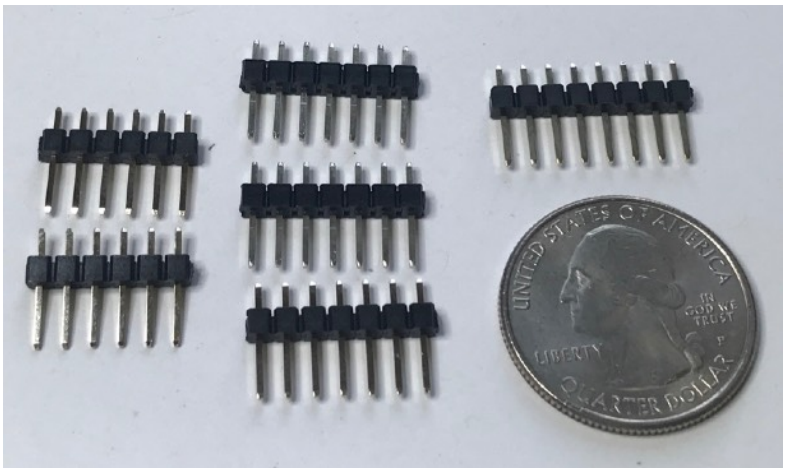




4. Install header pin segments.

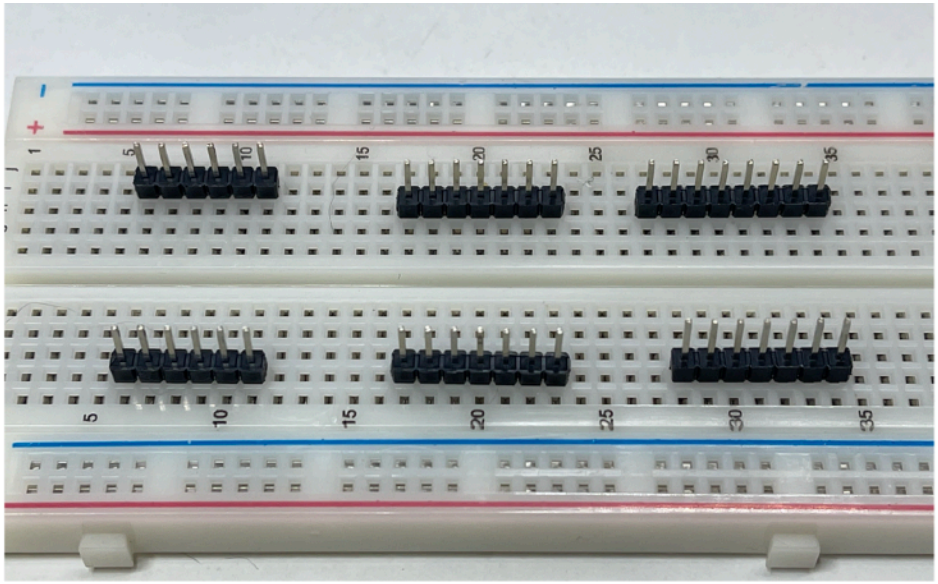
4.1 Prepare headers: trim or snap to length.

- ☐ 2 pieces at 6 pins long
- ☐ 3 pieces at 7 pins long
- ☐ 1 piece at 8 pins long

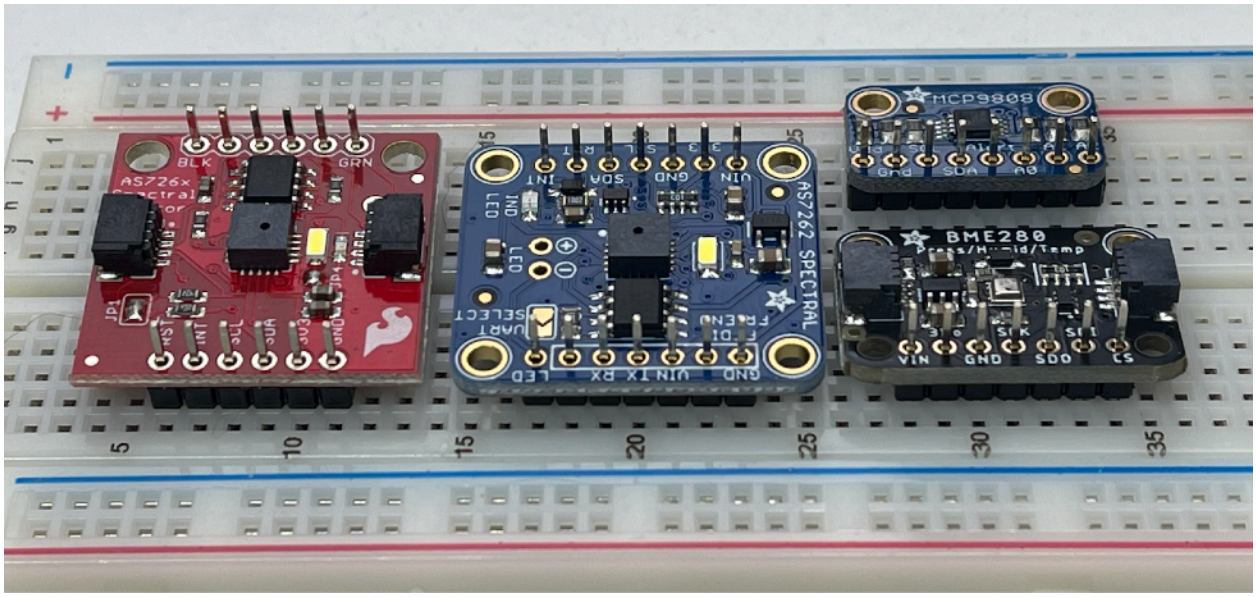


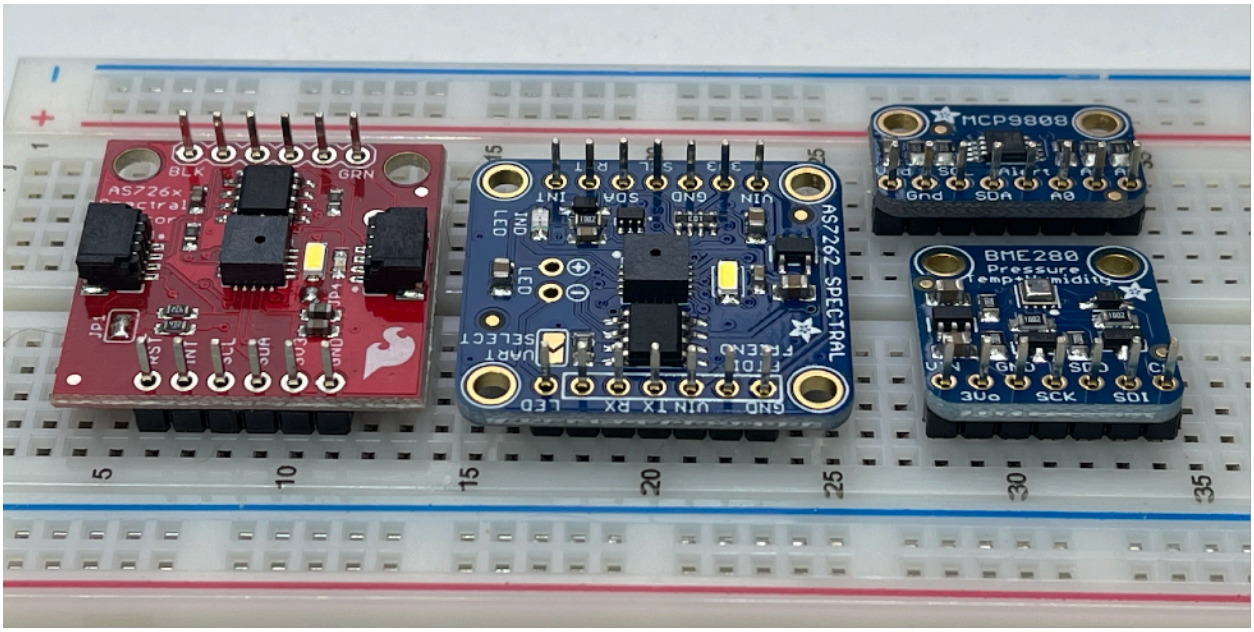
4.2 Push headers into breadboard. Push the shorter end of the pins into the breadboard. It's a bit tricky to get them to stay.

- ☐ 6-11 B (6 pins)
- ☐ 6-11 I (6 pins)
- ☐ 17-23 B (7 pins)
- ☐ 17-23 H (7 pins)
- ☐ 28-34 B (7 pins)
- ☐ 27-34 H (8 pins)

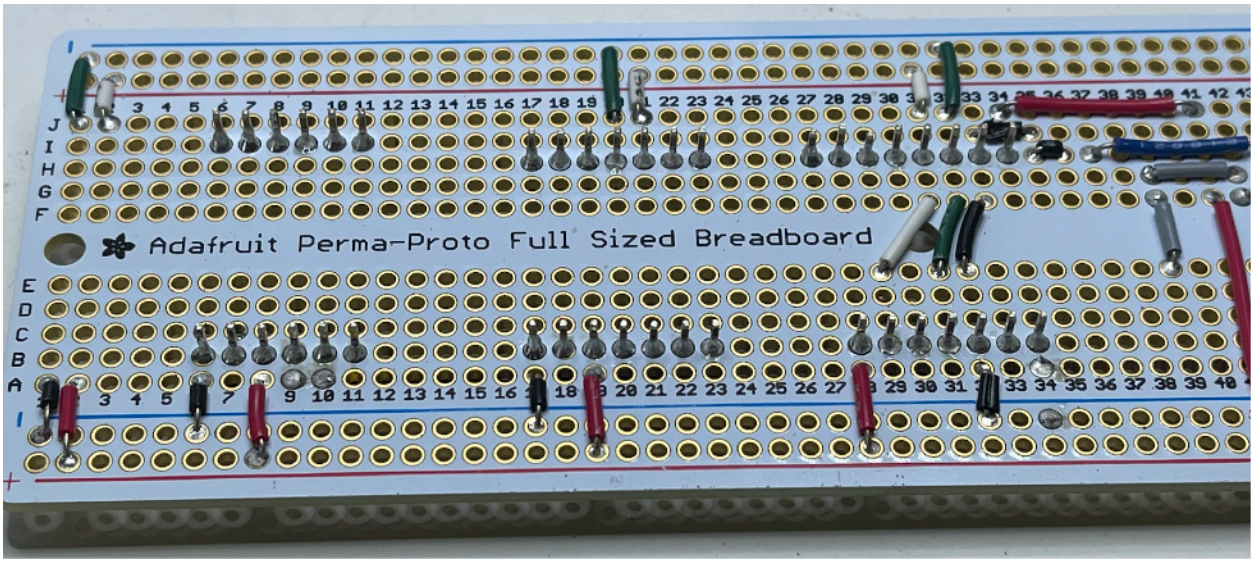


□ Confirm the header placement by temporarily placing the sensors, as a fit-check. Do NOT solder the sensors to the pins at this step. Remove the sensors after the fit check.

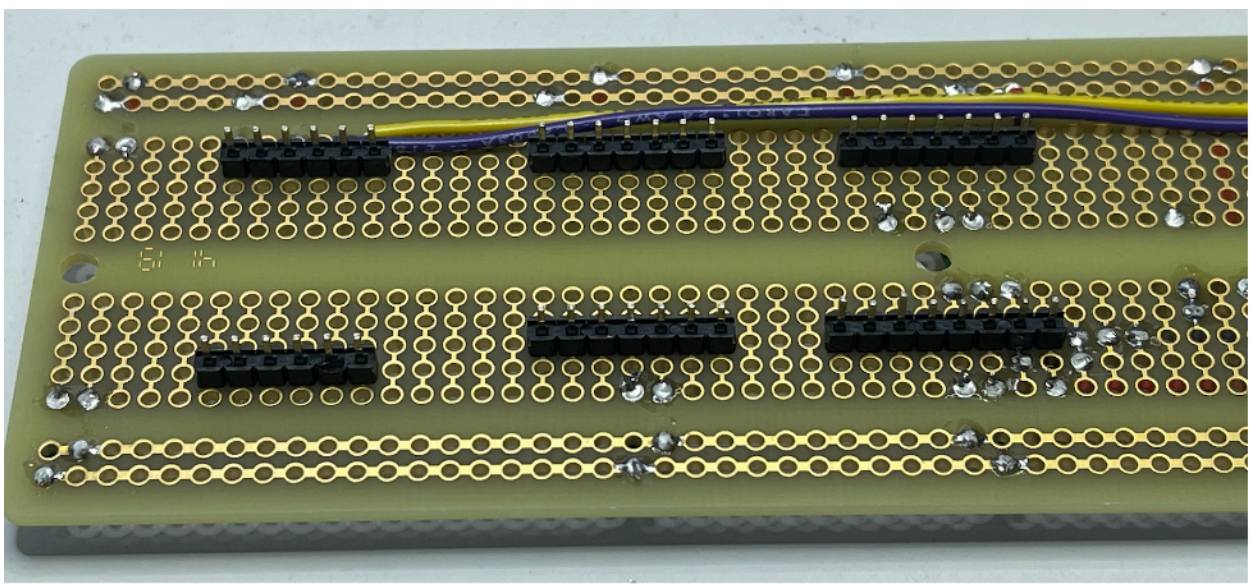




4.3 Solder the header pins onto the breadboard.
□ Lay the protoboard on top of the pins on the breadboard. Use the helper spacer under the far end of the proto board to keep the board flat.
□ Confirm the alignment by checking pins show in holes B6-11, B17-23, and B27-33.
□ Solder. B6-11, I6-11, B17-23, H17-23, B28-34, H27-34.



□ Remove the protoboard from the breadboard, by rocking gently but firmly, to separate the two without bending the header pins.

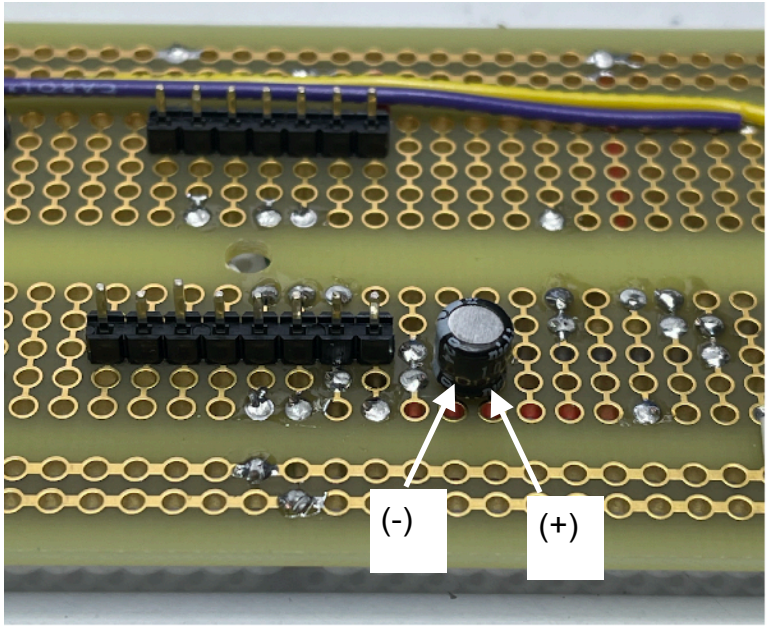


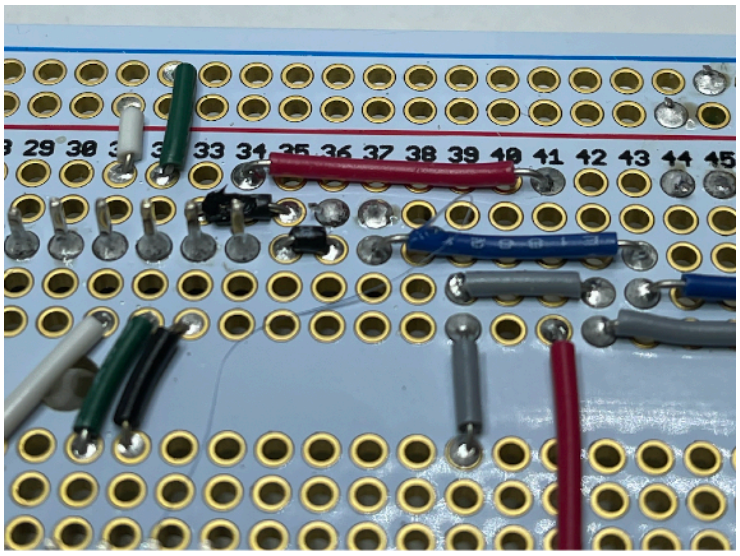
5. 10μF capacitor

Back: Install at two points. Be careful to install in correct polarization.

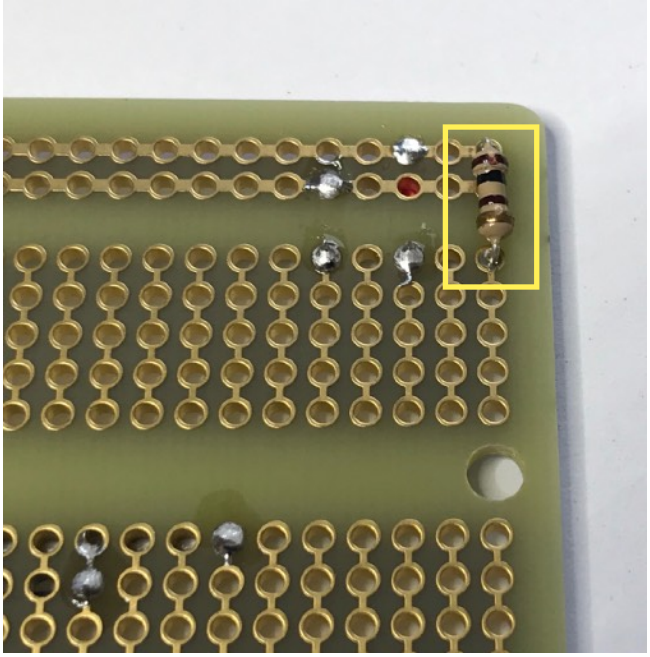
□ - lead into I36 (white stripe)

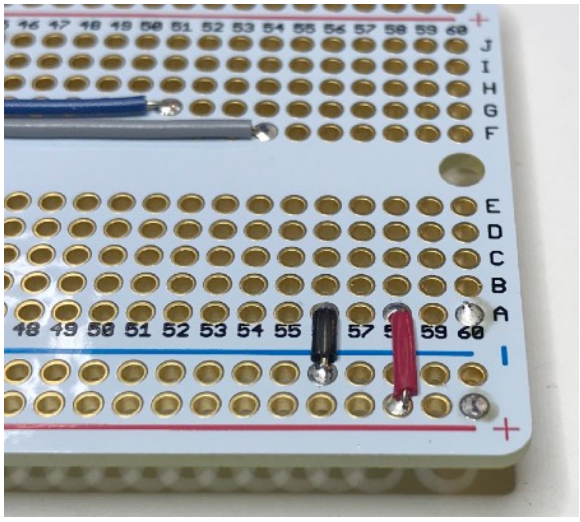
□ + lead into I37

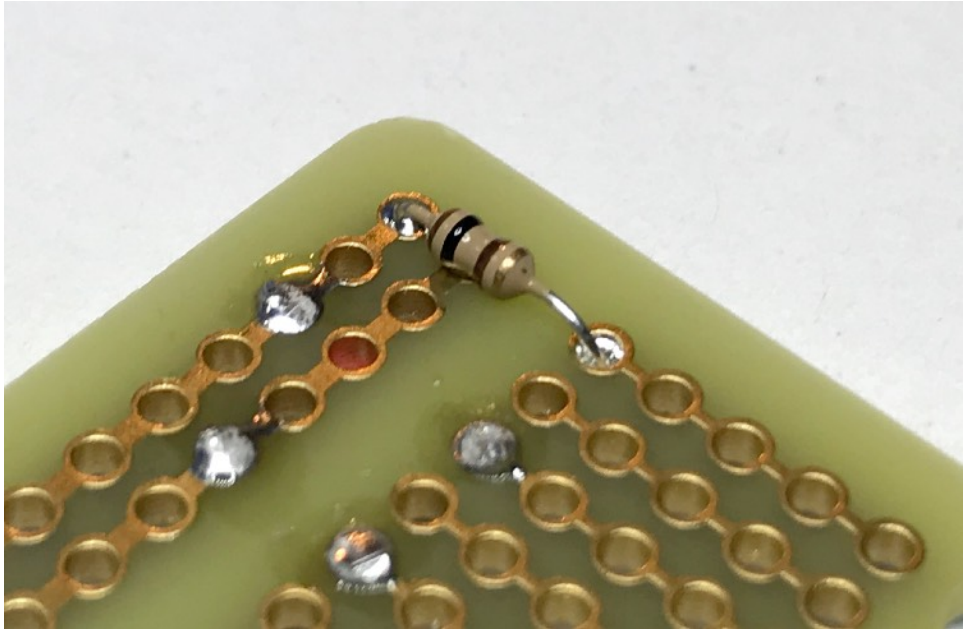




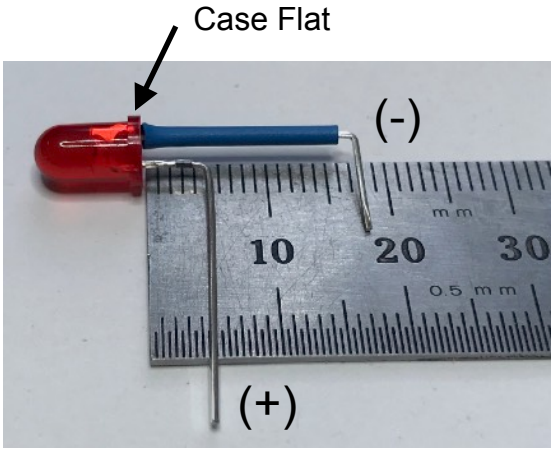
6. Install the 100Ω resistor.
Back:
□A60 to (+) bus.



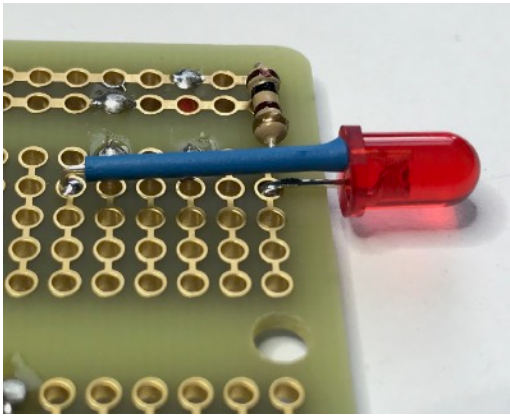


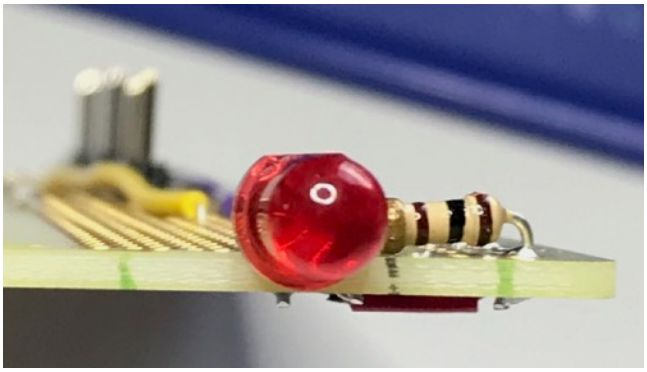


7. Bend and install LED.
□ Identify the negative lead: locate the flat on the case. That's the negative side.
□ Bend the positive lead at 5 mm (1/4") from the case
□ Slip a piece of heat shrink tubing, 15 mm long, on the negative lead.
□ Bend the negative lead at 18 mm (3/4") from the case.



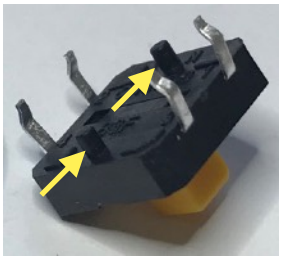
Back: Connect two places:
□ positive lead to B60
□ negative lead to B55

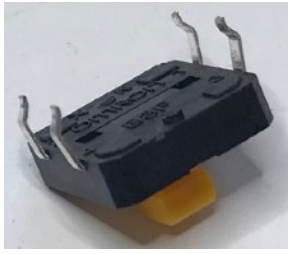


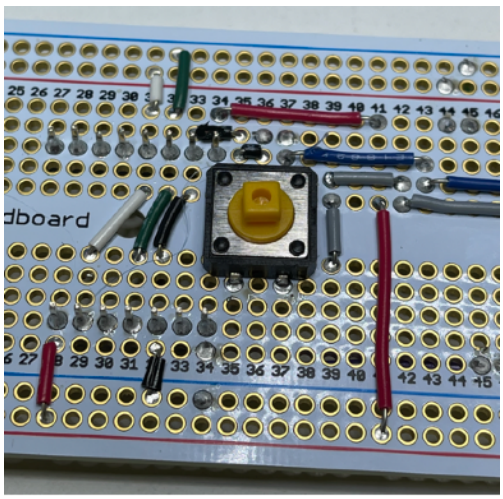


8. Install buttons.

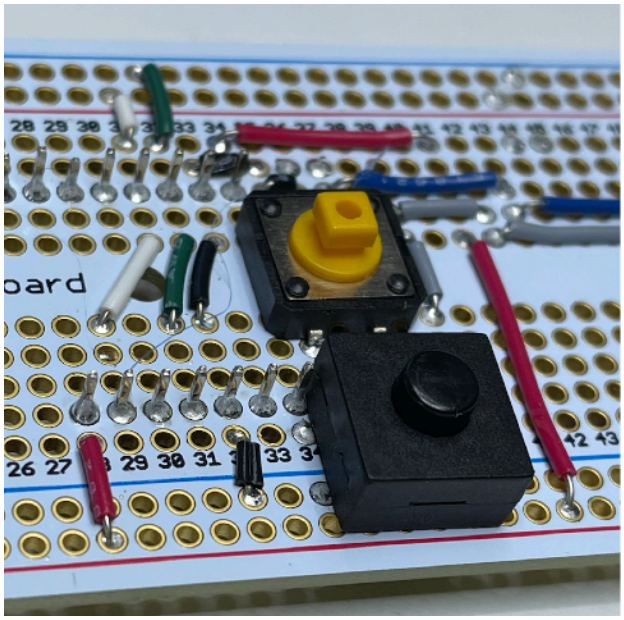
8.1. Pushbutton, 4 leads.
□ Trim off the plastic posts.
□ Front: G35, G37, D35, D37

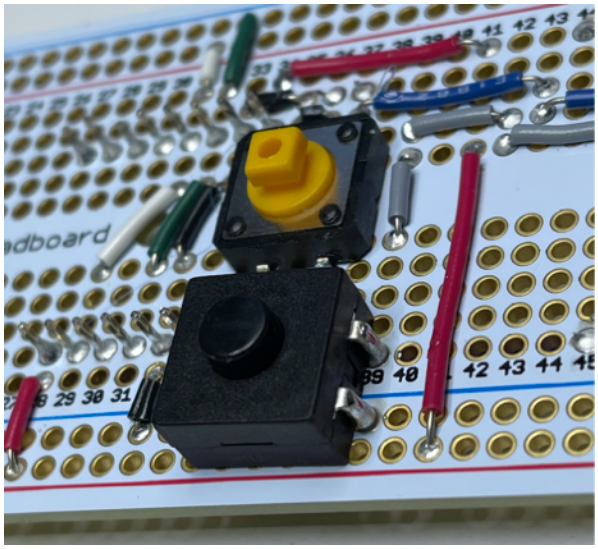




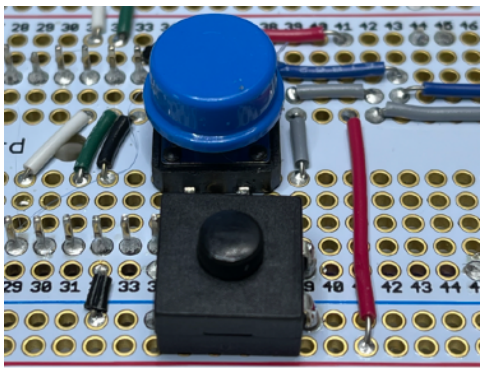


8.2. Power button, 2 leads.
□ Optional: Apply thin film double stick tape to the back of the switch, to hold it in place on the board.
□ Front: A39, (-) bus.



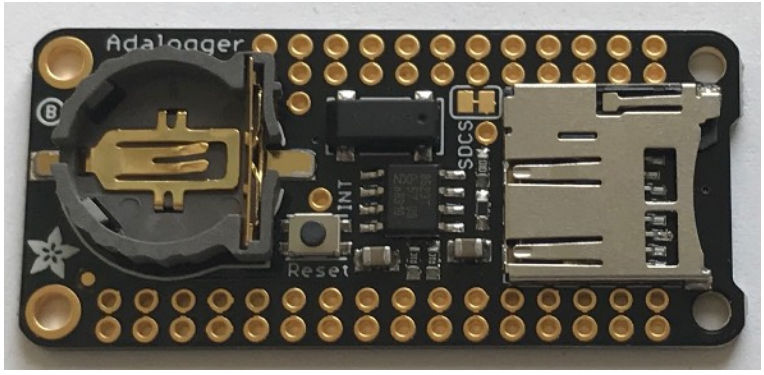


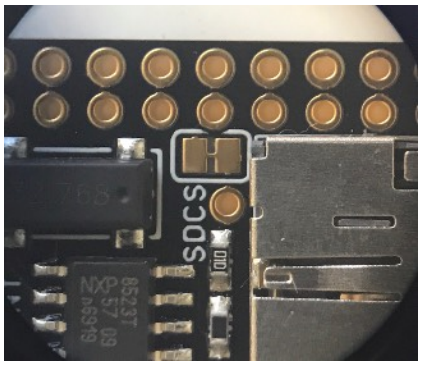
8.3. Install the the pushbutton switch cap.
□ Press the cap into place.

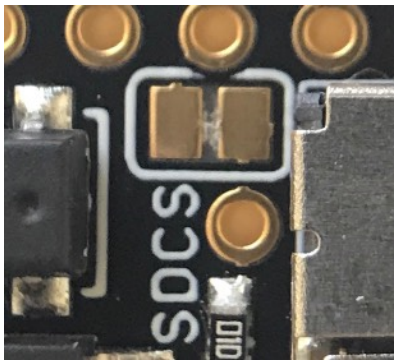


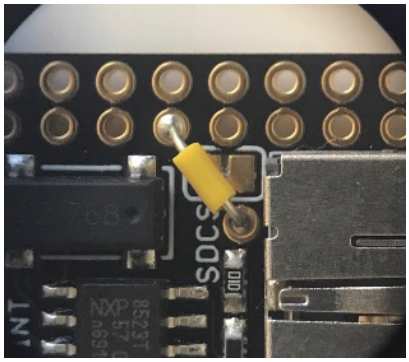
SDCS = Secure Digital card Chip Select line, part of SPI (Serial Peripheral Interface) communications

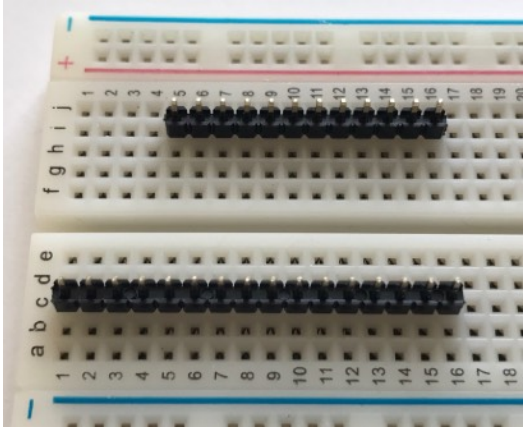
9. Modify and assemble the datalogger board.
□ Cut the circuit trace, marked SDCS, on the front of the board.
□ Run a new SDCS line to the pin number 11 (yellow wire).

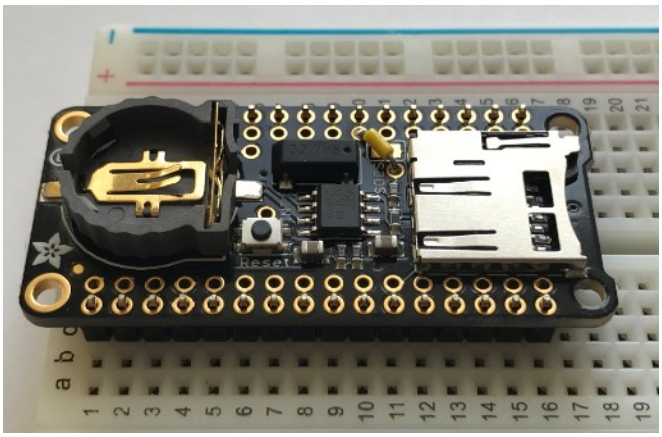








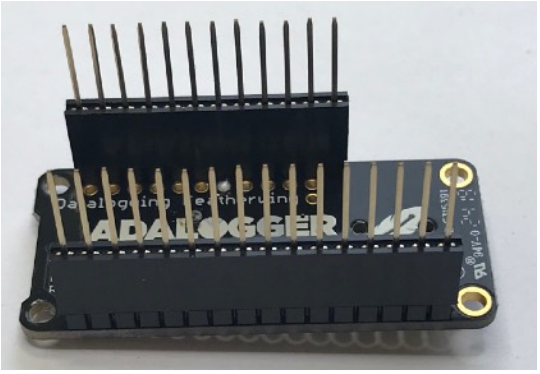




□ Push the headers into breadboard, inserting the longer end of the pins into the breadboard. You may want to use something flat to push with to keep the pins from sliding in their plastric holders to different heights.
□ Place the data logger board on the headers, on top of the breadboard.
□ Solder the header pins to the data logger card, 12 places and 16 places.
□ Separate the datalogger board from the breadboard.

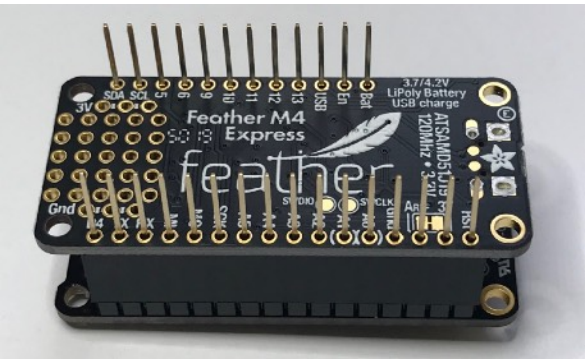
10. Processor.

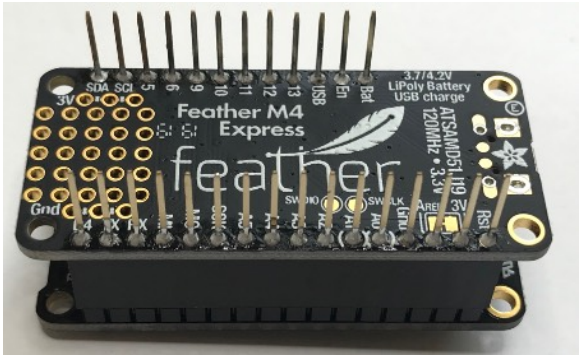
□ Push a set of stacking headers onto the datalogger card, to use the datalogger as a fixture to keep the headers at right angles to the processor board.



□ Mount the processor on the headers.

□ Solder each pin of the headers



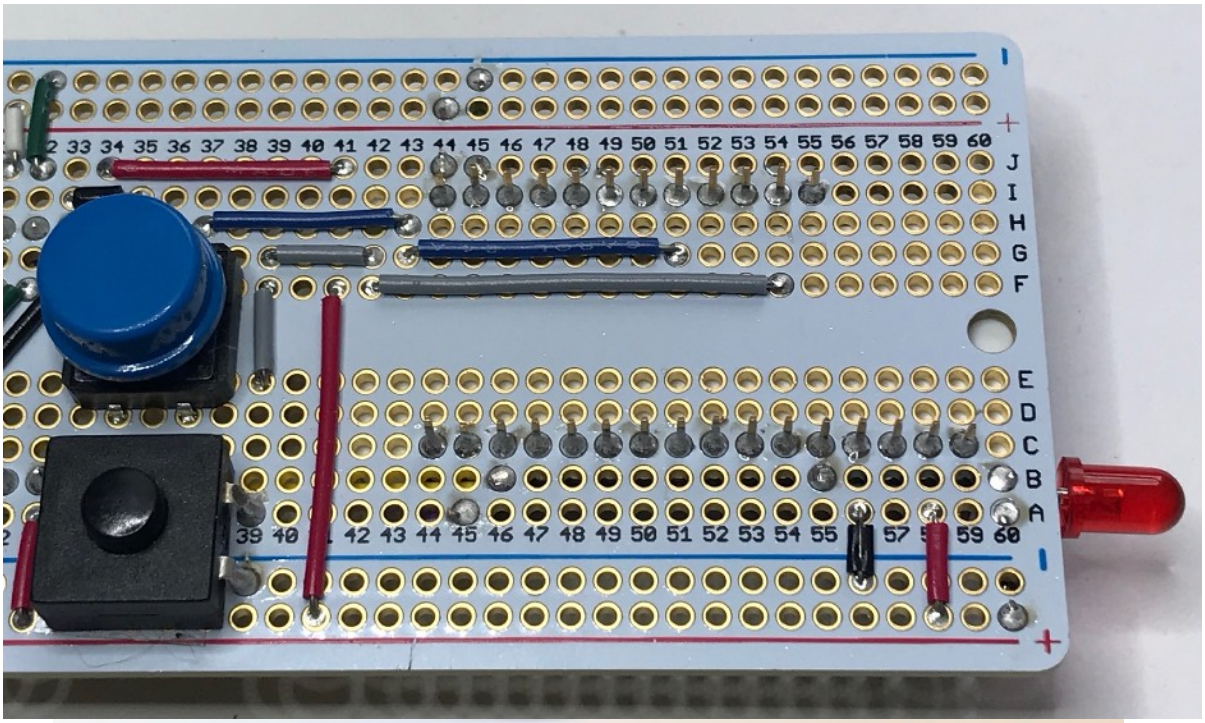


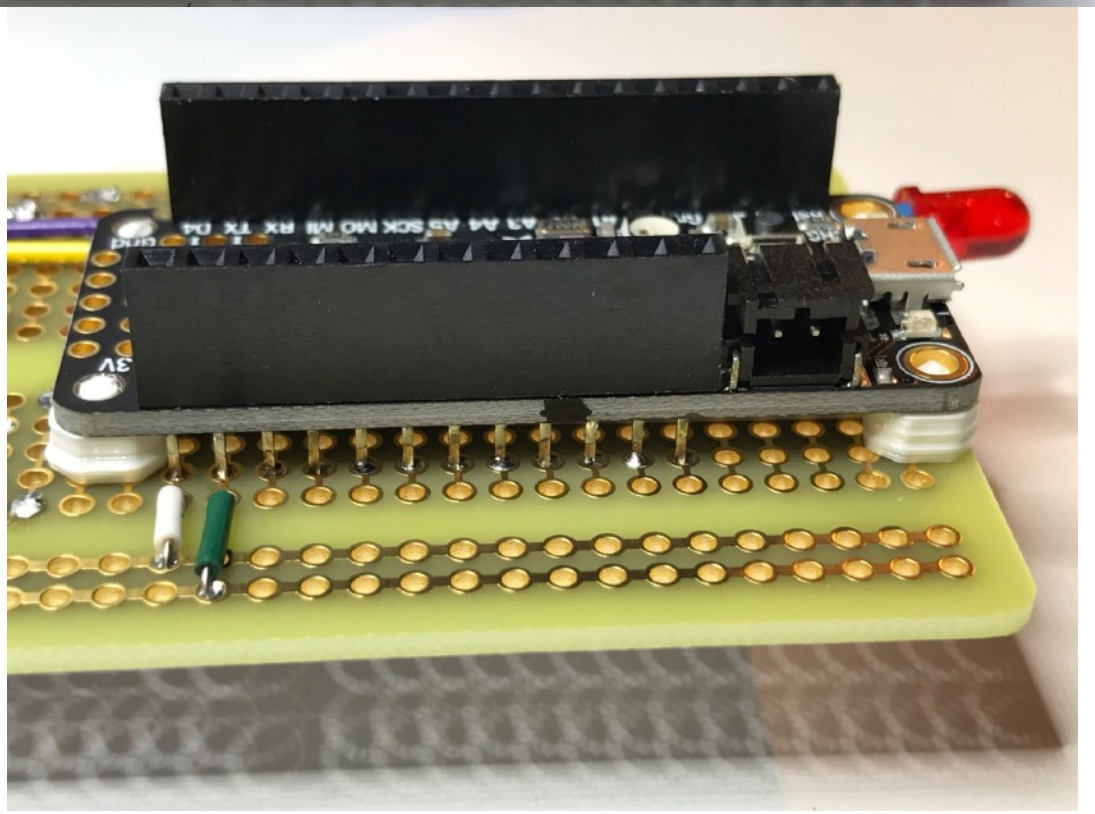
□ Place the processor spacer, printed in step 1, on the processor.

Photo TBD

□ Mount the processor to the protoboard, from the back, into C44-59, and I44-55.

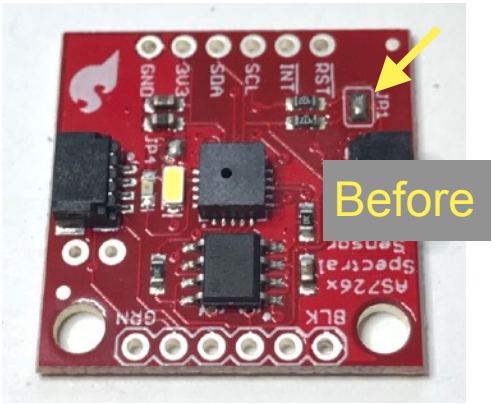
□ Carefully solder the header pins to the protoboard. The exposed pins act as the connection to the display, so it's important to keep the ends of the pins free of solder.

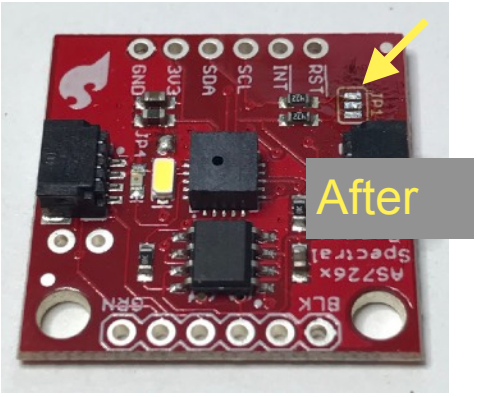




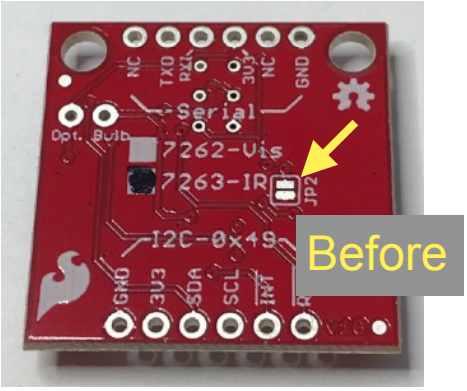
11.1. Modify the NIR sensor:

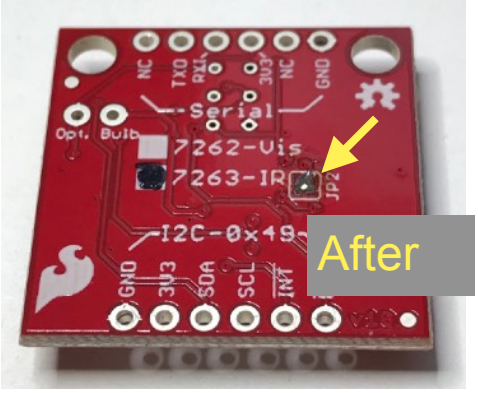
□ Remove solder from jumper set JP1 (on the component side of the board)





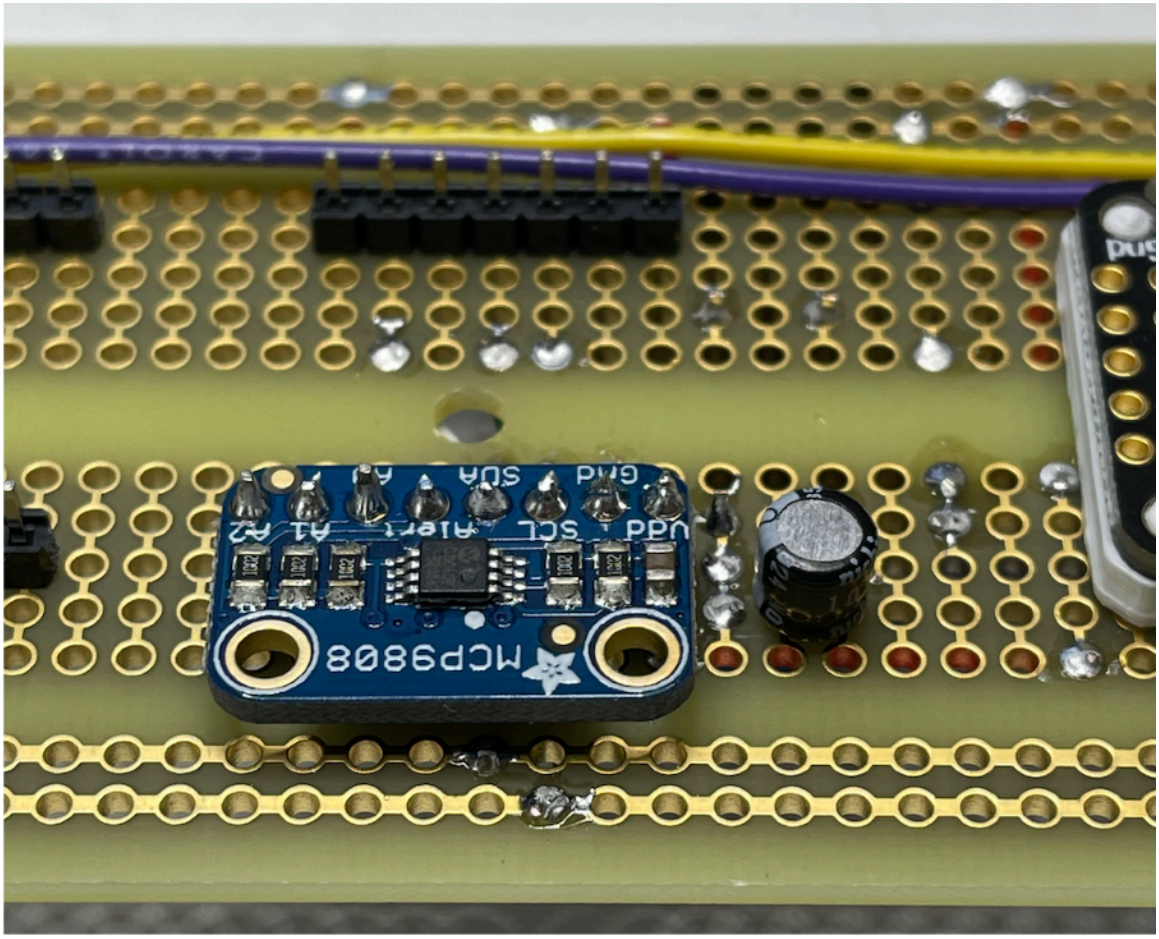
□ Add solder to the jumper JP2 (on the back of the board)



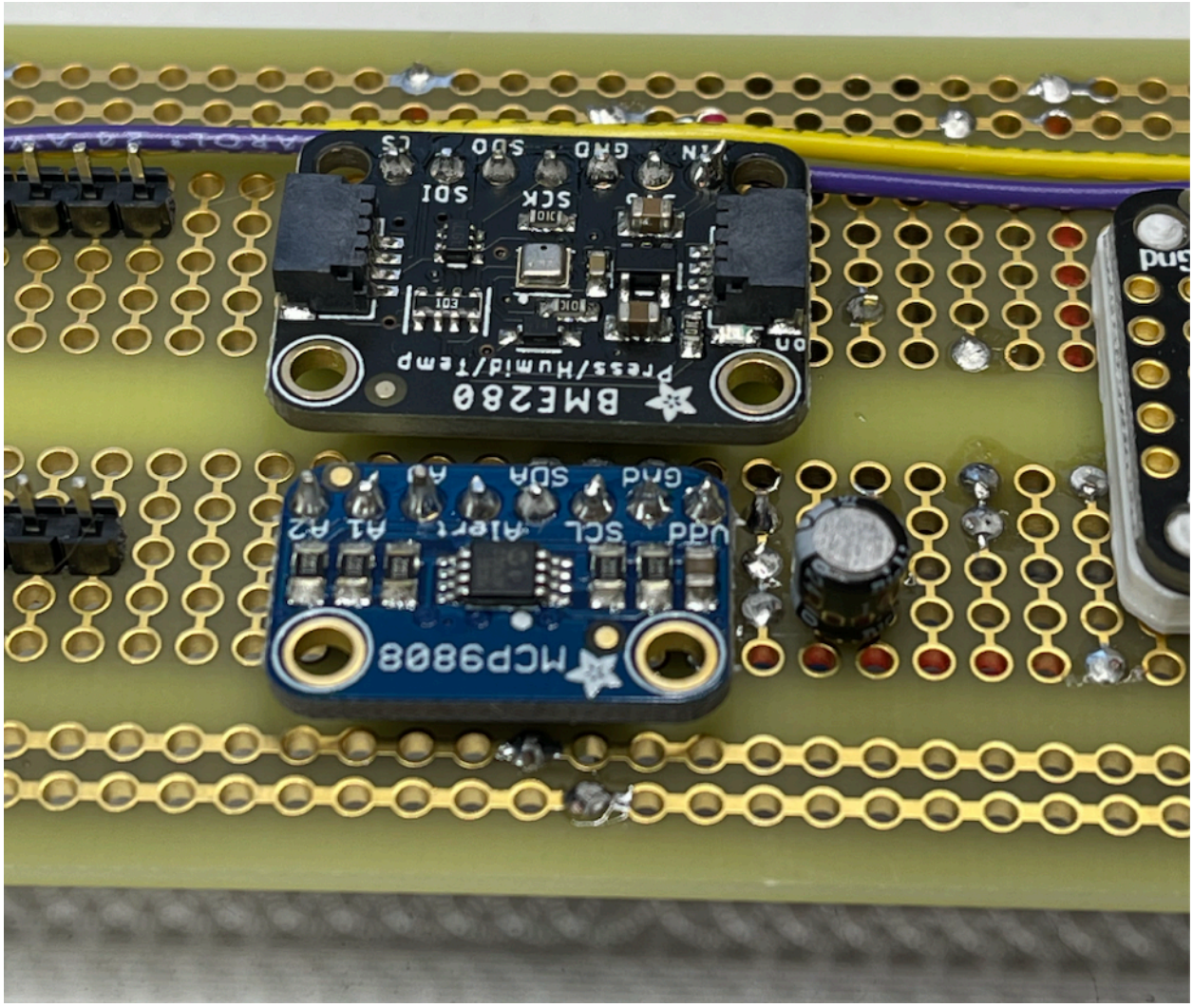


11.2. Install sensors in this order:

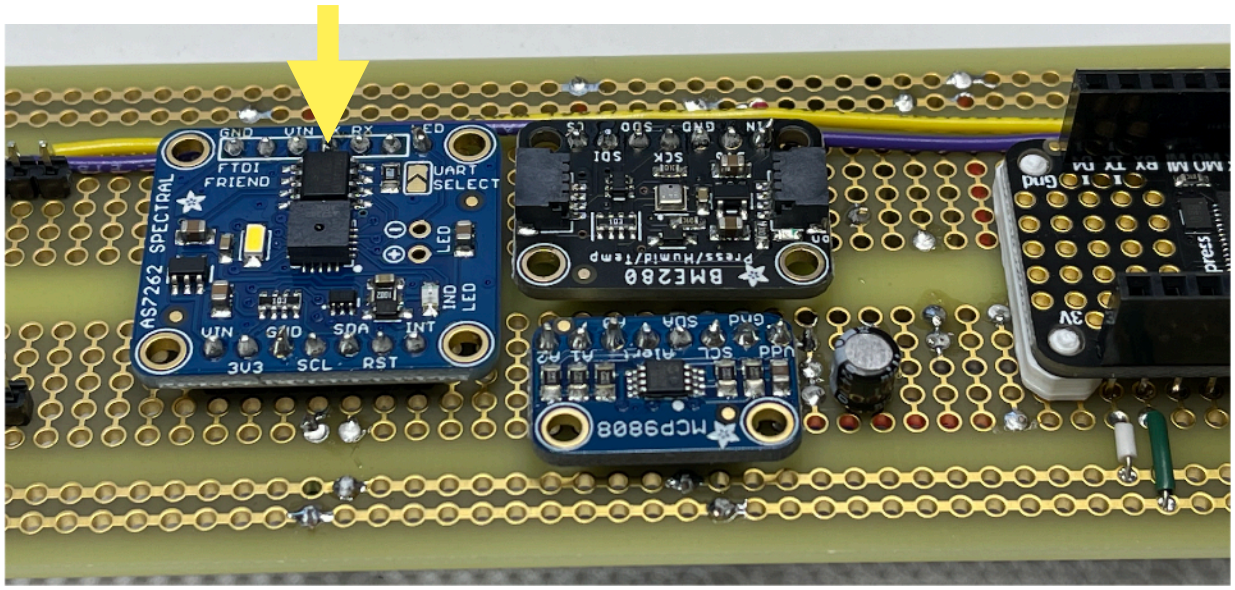
□ AT -- Install the Air Temperature sensor face up, on the back of the main board, on the header with 8 pins. Orient the sensor so that it sticks out towards the SCK and SDA connections. To get it to sit flat, solder one pin only, at first. Then remelt that solder connection and lift the sensor board by hand to make it flat. Remove the soldering iron and let the connection cool. Then solder the rest of the connections. Solder 8 places total.



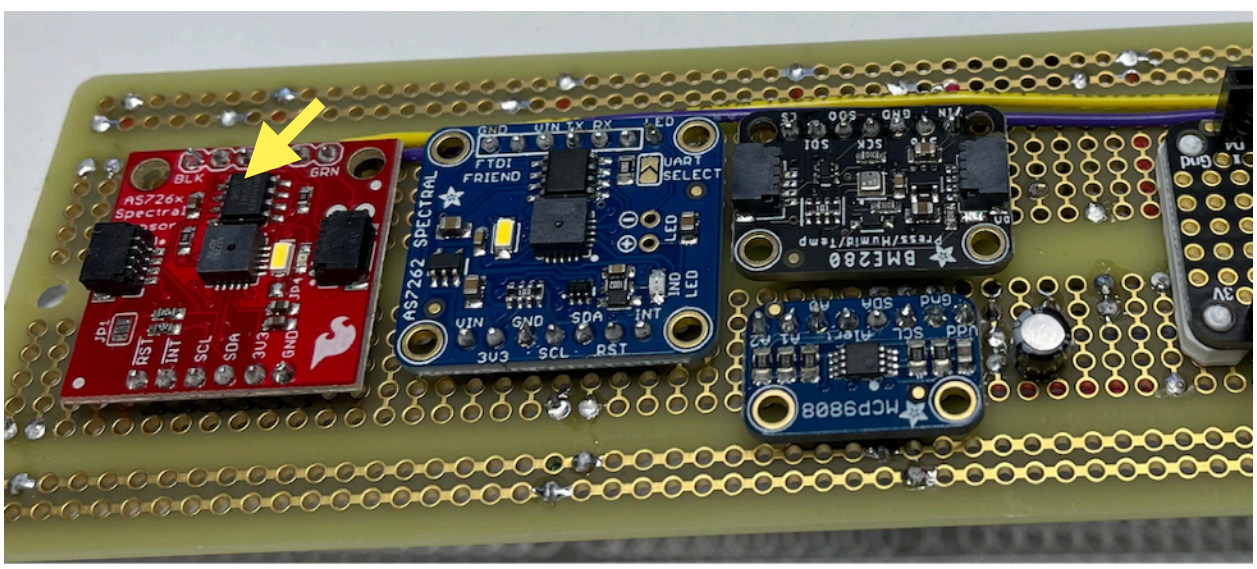
□ WX -- Install the Weather sensor face up, on the back of the main board, on the header with 7 pins, across from the AT sensor. Orient the sensor so that it sticks inwards towards the AT sensor. To get it to sit flat, solder one pin only, at first. Then remelt that solder connection and lift the sensor board by hand to make it flat. Remove the soldering iron and let the connection cool. Then solder the rest of the connections. Solder 7 places total.



□ VIS -- Install the Visual spectrum sensor next to the two previously installed sensors. Make certain that the auxiliary communications chip (yellow arrow) is on the same side as the WX sensor. Solder 14 places.

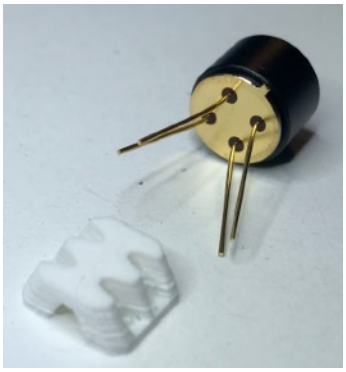


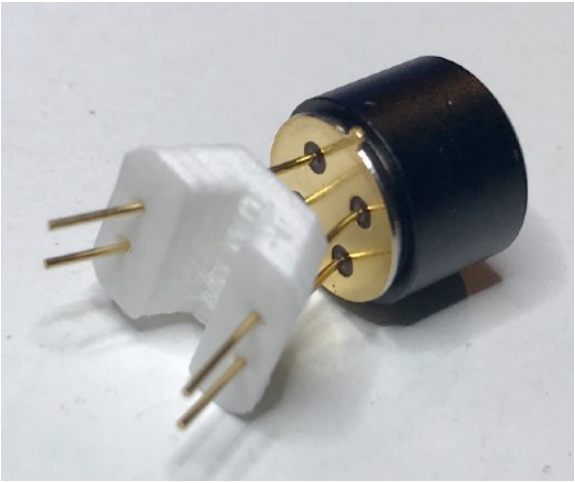
□ NIR -- Install the Near InfraRed spectrum sensor, next to the VIS sensor. Make certain the auxiliary communications chip (yellow arrow) is on the same side as the corresponding chip on the VIS sensor. Solder 12 places.

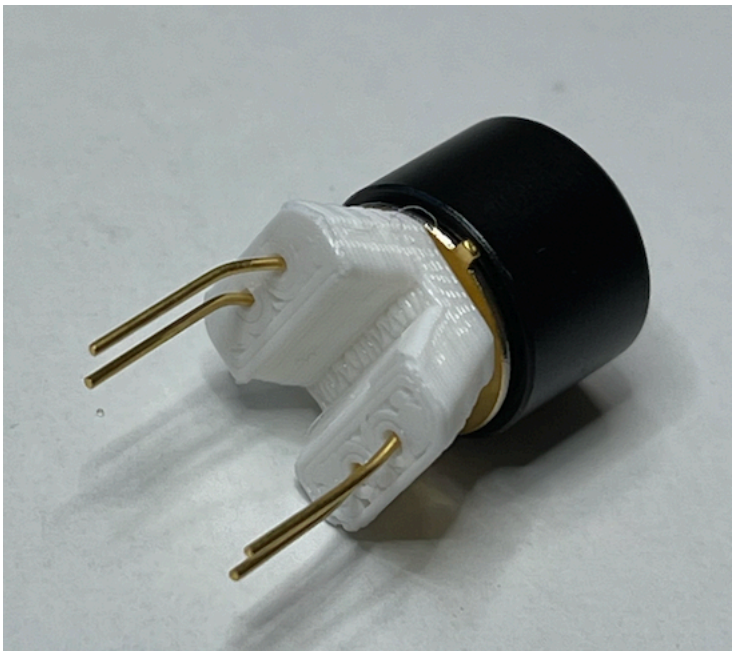


□ TIR -- Install the Thermal InfraRed non-contact surface temperature sensor at the end of the board.

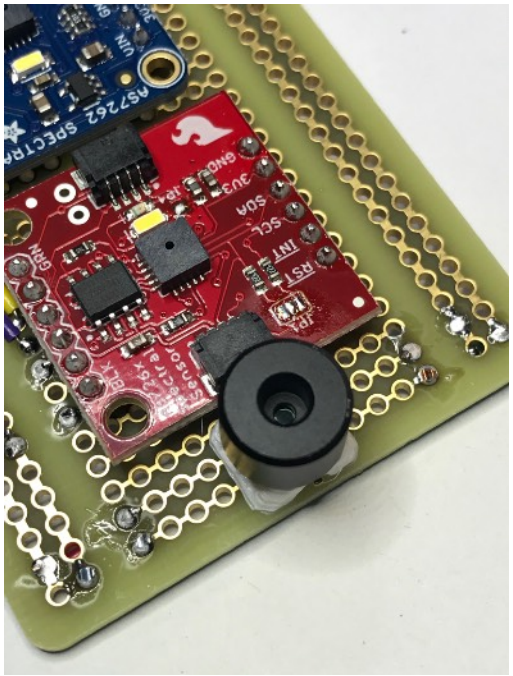
-- Bend the leads to fit into the spacer, then insert the leads into the holes in the spacer. The sensor orientation tab must protrude off one of the flat sides of the spacer.

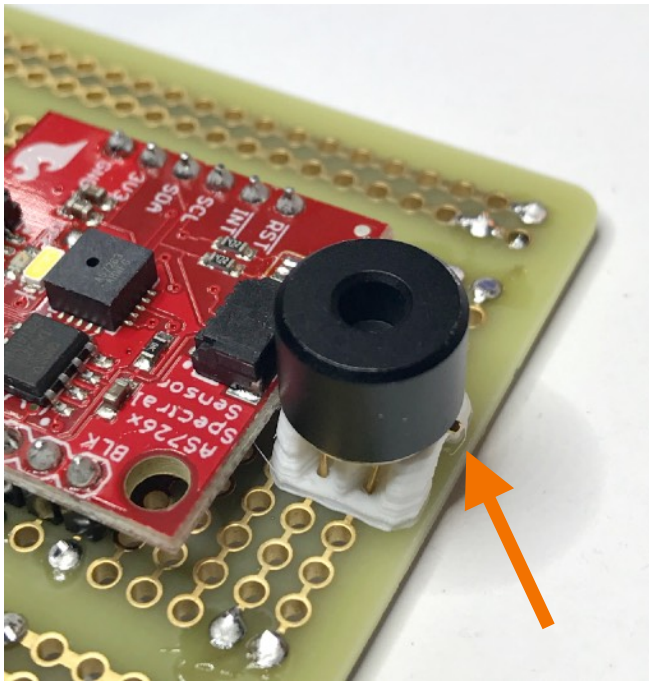


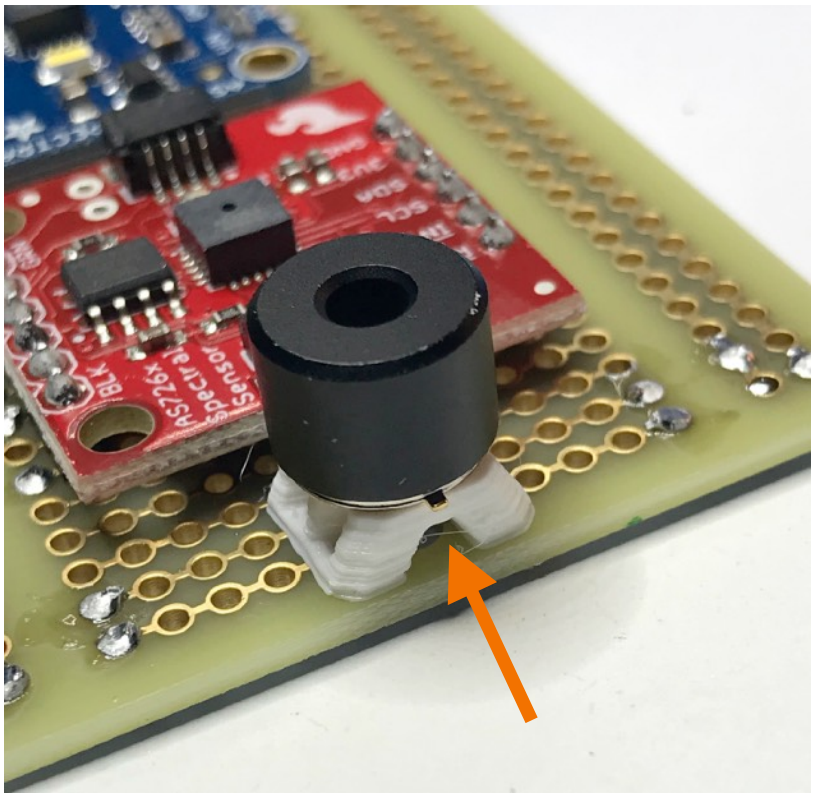




-- Push the sensor flat to the spacer, then re-bend the leads to match the holes in the board.
-- ***The sensor tab must point off the end of the board.***
-- Solder the leads, 4 places, on the front of the board, then trim off the excess.





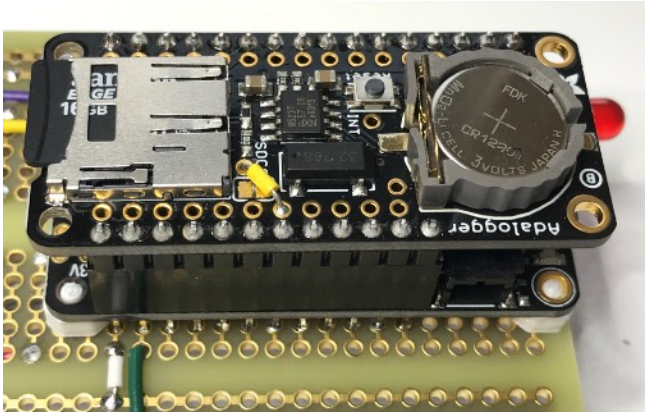


12. Mount the remaining components.

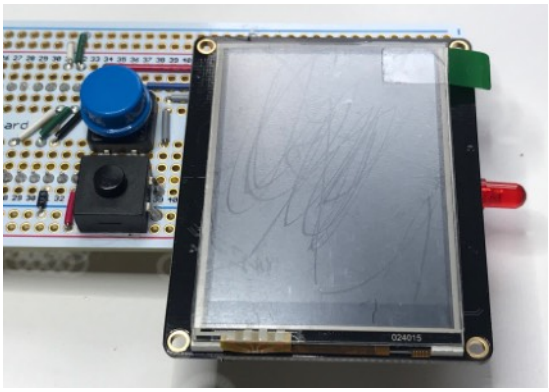
□ Datalogger card -- mount the data logger card onto the processor by carefully aligning all the pins and pressing until it seats on the processor.

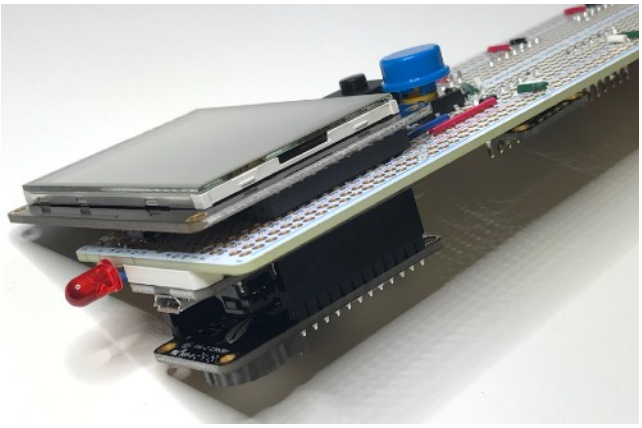
□ Clock battery -- Clean the battery surface with isopropanol and a paper wipe (paper towel, toilet paper, lens cleaning tissue) before installing it, to help keep the battery in good contact with the clock module. Drop the battery into the grey holder, starting with the side away from the gold retaining spring. Then press the battery down flat, until the retaining spring clicks onto the top of the battery to hold it in place.

□ microSD memory card -- Press the microSD card into the connection slot. Press to seat it. Press a bit more to unlatch it, when you want to remove it.

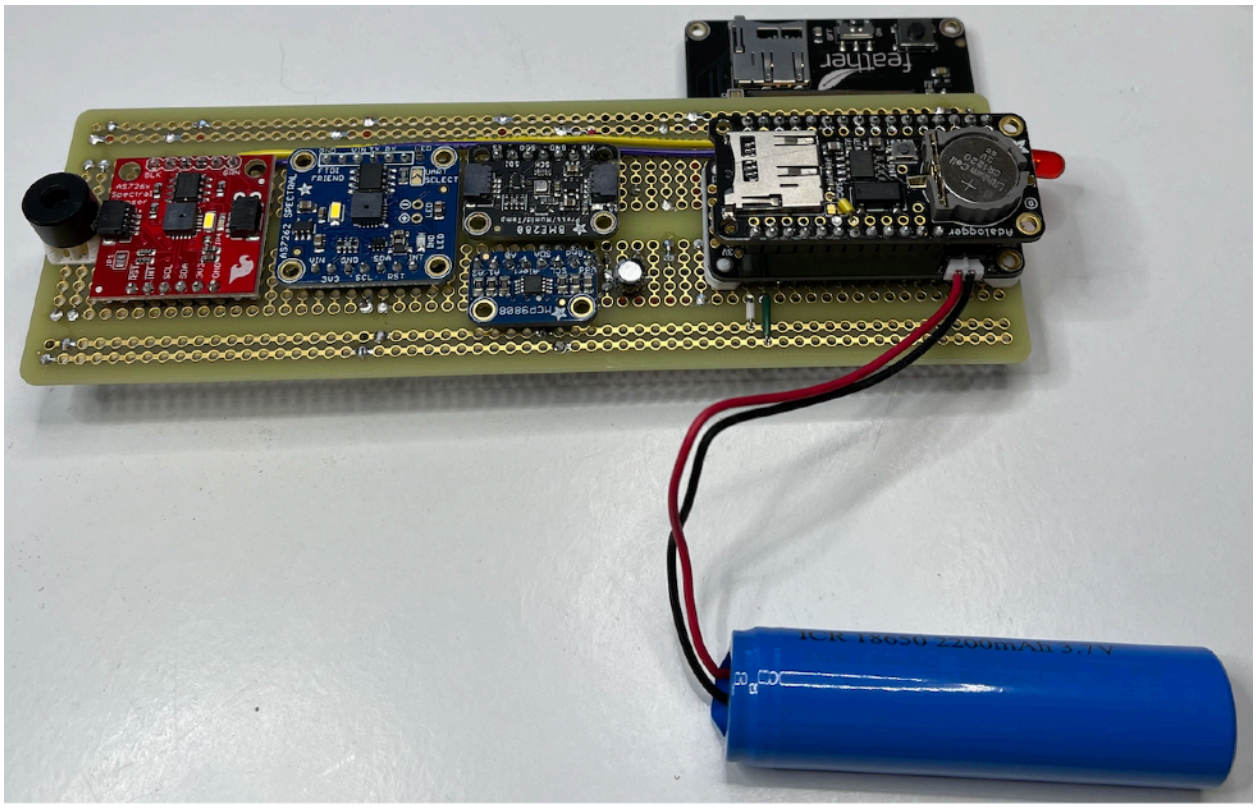


□ Display -- Very carefully position the display so that the socket connectors on the display line up with the processor pins sticking up off the main board. There are two sets of sockets on the display. The pins should connect to the innermost set on both sides of the display. Press gently on the display to seat it onto the pins.

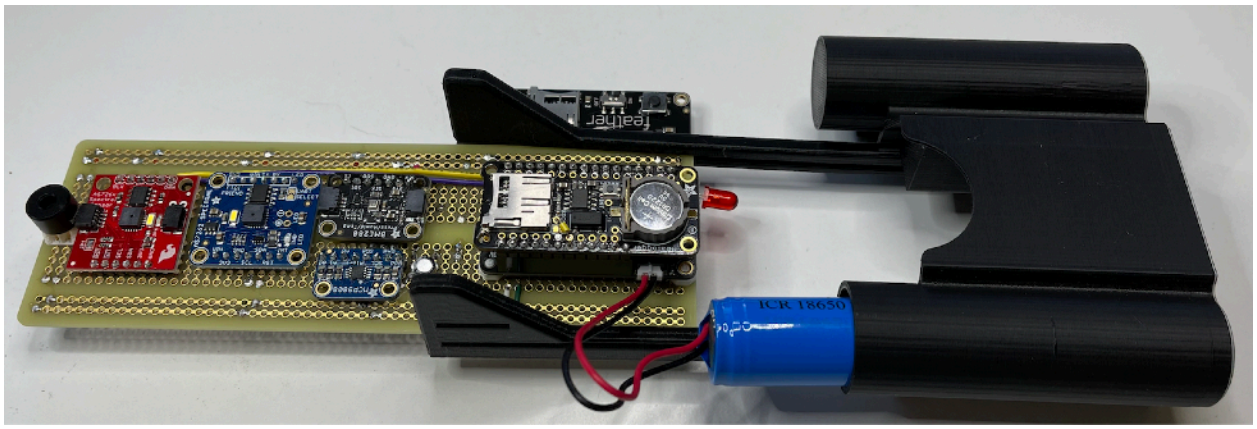




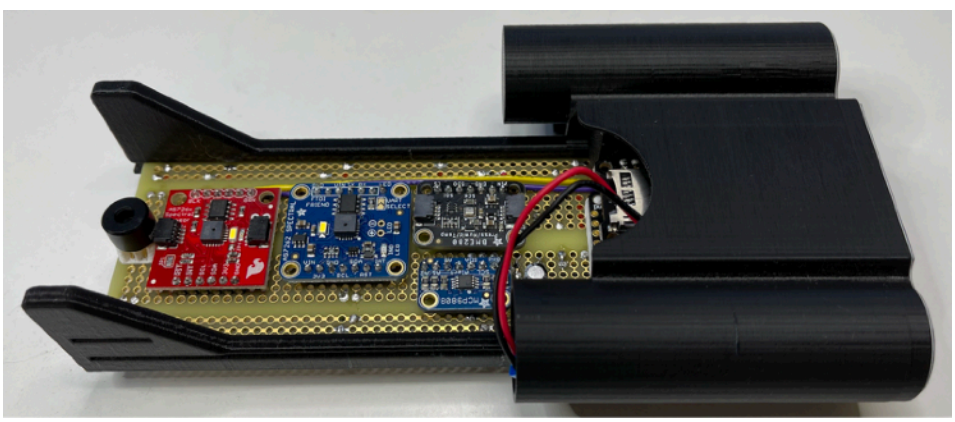
□ Main battery -- Plug the connector on the main battery into the battery socket on the processor. At this point, whether the power button is on or off, the battery can be charged by connecting the instrument, at its micro b connector, to a USB power source. Do not attempt to charge the battery without the processor.

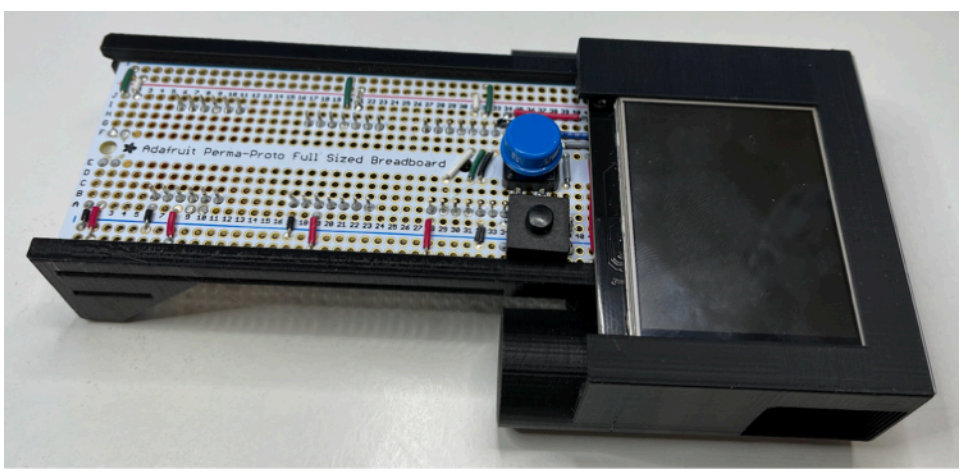


13. Assemble the STELLA instrument.
□ Slide the protoboard into the board edge guide slots on the lower housing.
□ Lower the battery into the cylindrical recess, as you slide the board all the way into the housing. You may need to press on the display on one side or another to get it to sit flat, so it will fit into the housing.

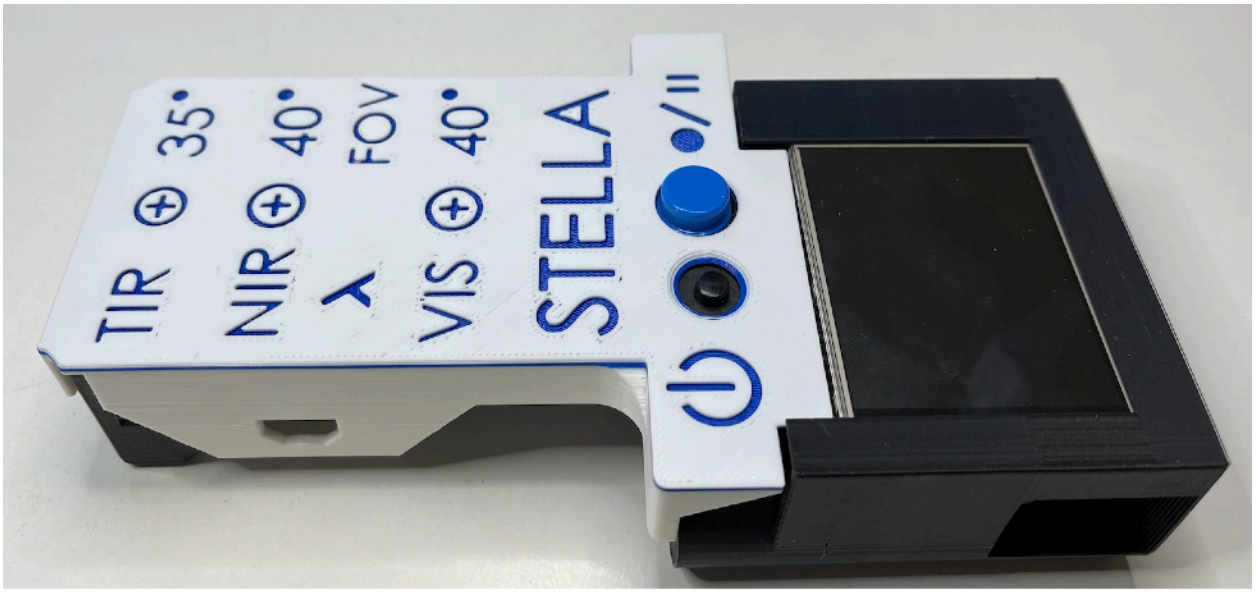


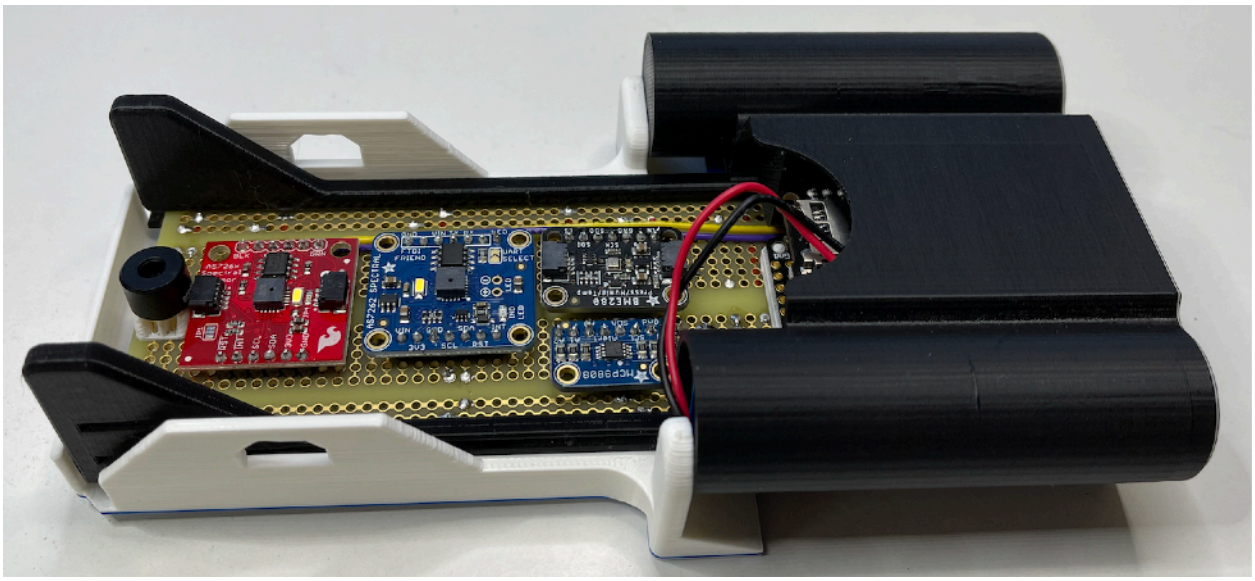
□ Check that the LED is aligned with the hole, then slide the instrument into the housing completely.



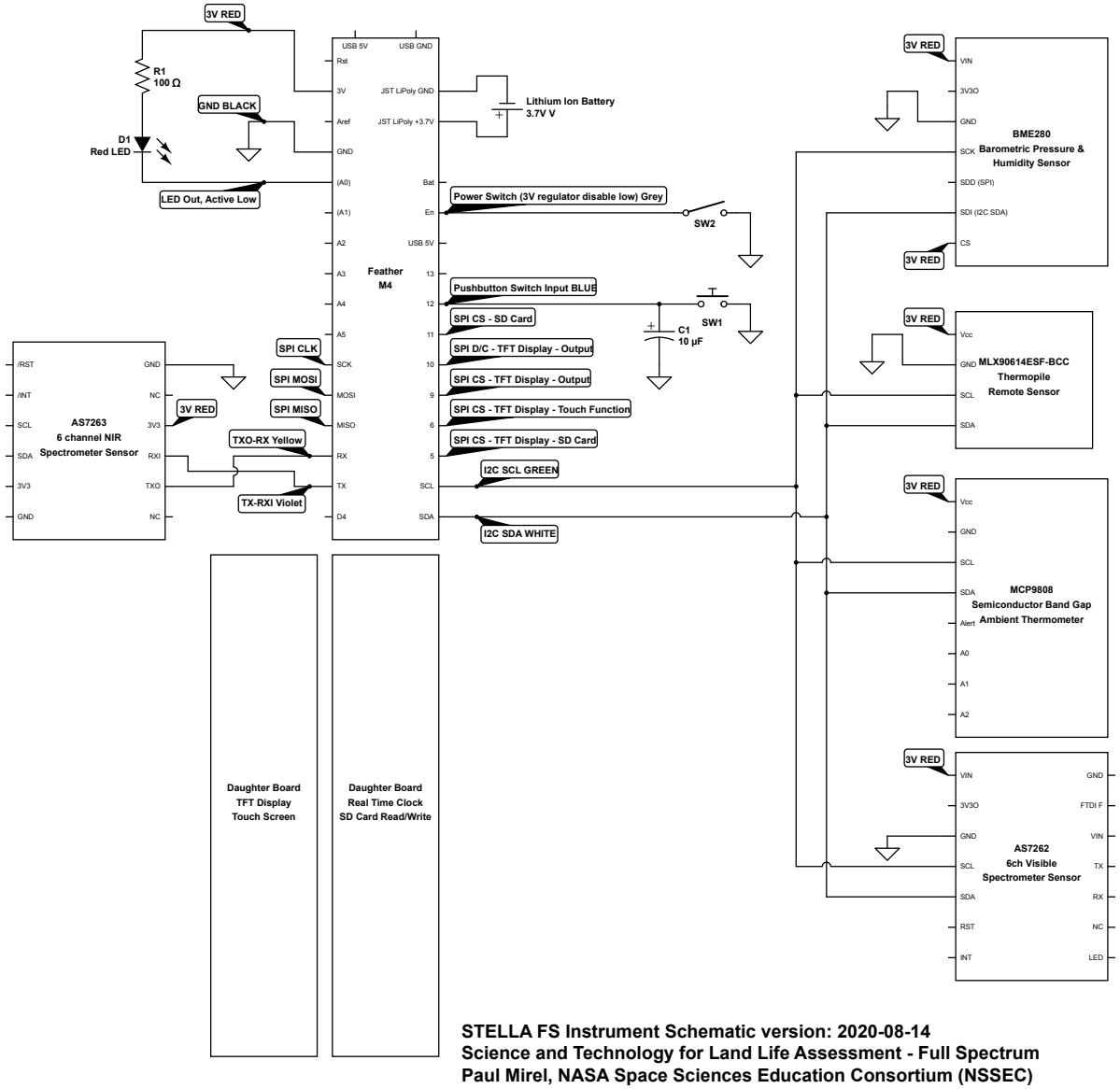


□ Install the housing cover from the top, aligning the cover over the pushbuttons. Snap the housing cover onto the housing. (Do not slide it on from the end. It's designed to align with the buttons, to install from the top. You may need to apply some light spreading force on housing cover tabs to get it to snap onto the housing.)





STELLA Instrument Schematic:



STELLA FS Instrument Schematic version: 2020-08-14
Science and Technology for Land Life Assessment - Full Spectrum
Paul Mirel, NASA Space Sciences Education Consortium (NSSEC)

Revision Notes:

20200805: Correct wiring error on TX and RX lines at NIR sensor.

20200814: Add capacitor, and associated ground wire, in step 3.4.

20200817: specify capacitor wiring locations, and associated ground wire location.

20201130: change capacitor mounting location to the back of the board. change the assembly order to install the capacitor after the header pins.

20210203: Major update, including change to 35º FOV sensor as default TIR.

20210325: Major update to accommodate new form factor (connectors) on BME280 board. General improvements to clarity.

20210505: Identified and labelled wiring mistake in photos, page 14.