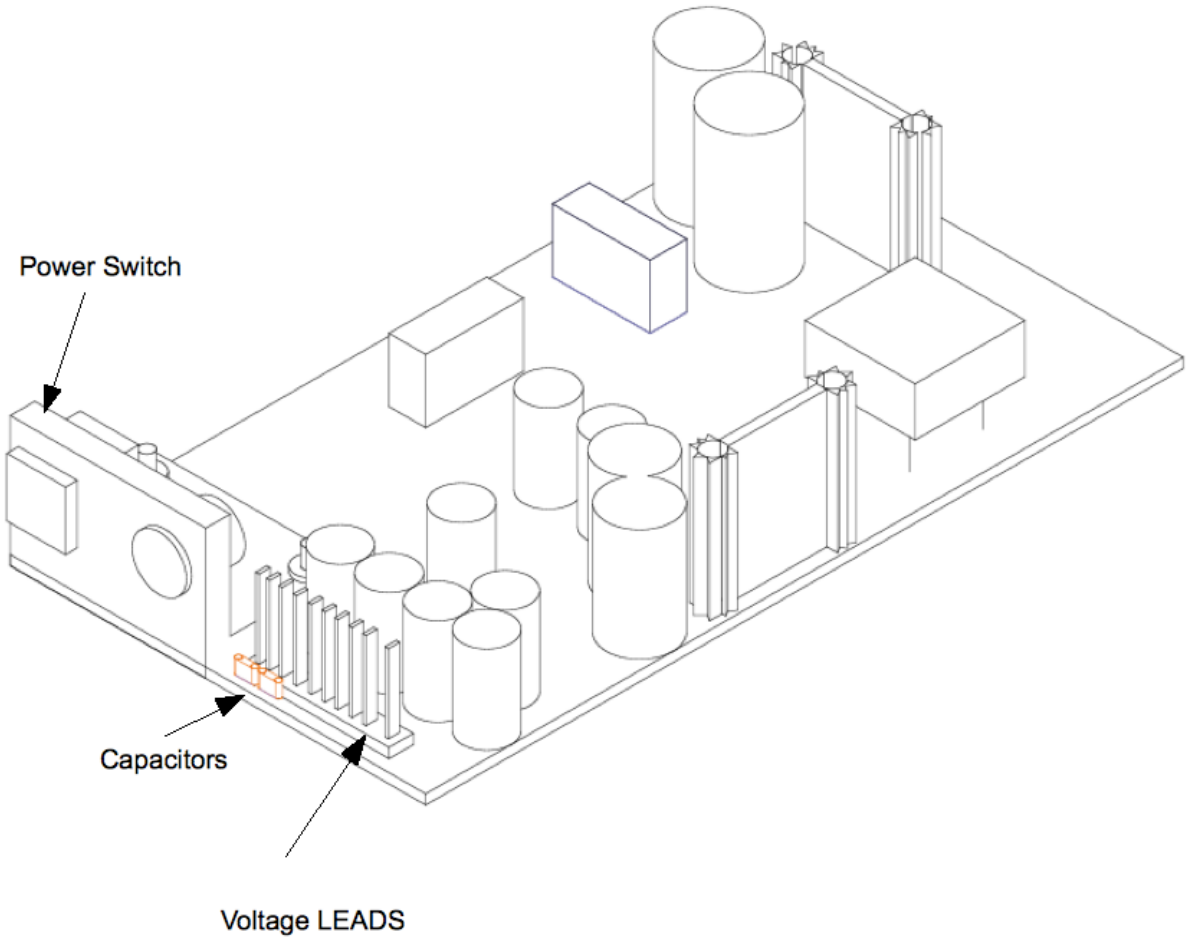
Power Supplies

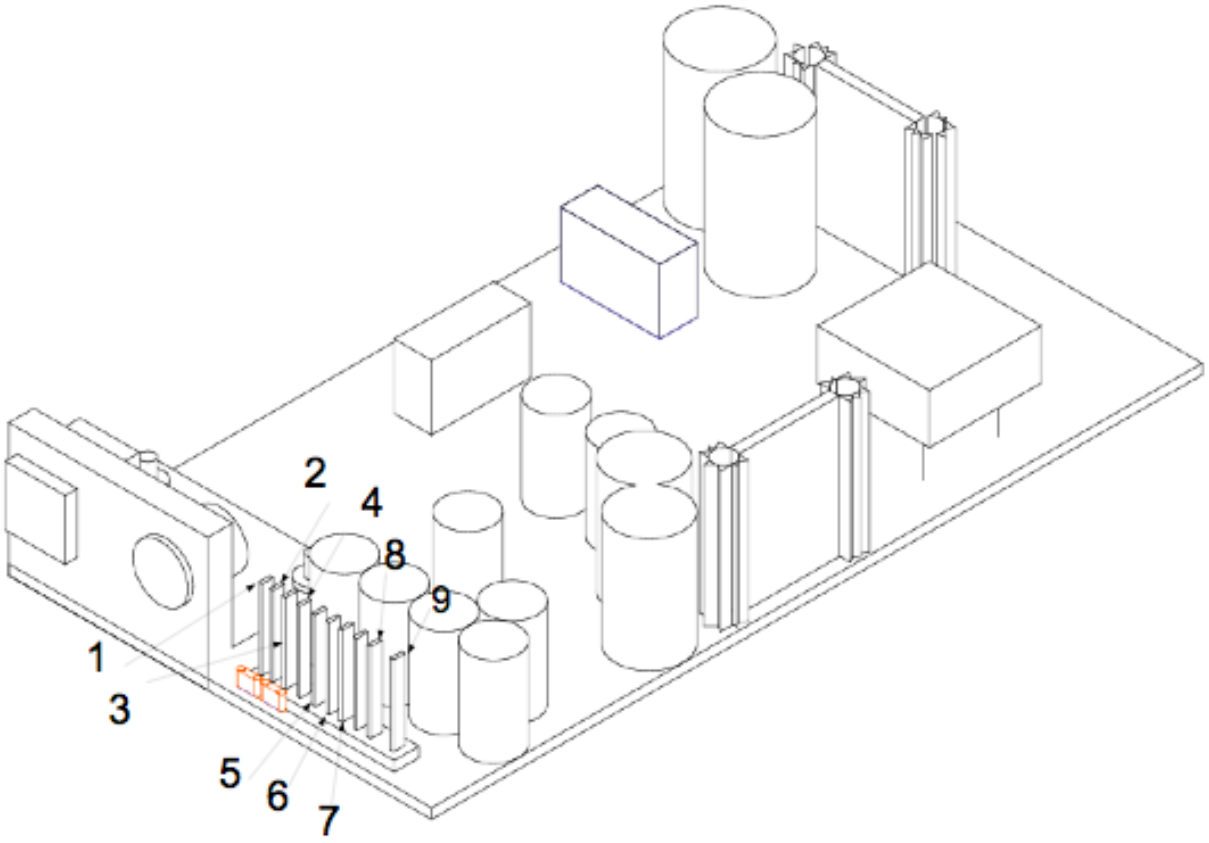
Testing Low Voltage Supplies

Before we can construct power supplies for the use of running the particle detectors, we have to test the individual pieces to ensure their functionality. When I was first working on the project, the previous generation of CROP workers had left no instructions on how anything was to be tested or built. After about a year of trial and error, I managed to create the first of the power supplies attributed to my generation of workers. I named it after myself (Tim Jr.). This supply was eventually given away to one of the schools to run their detectors and has yet to be returned to the project. Not getting power supplies returned (or if they are returned, they are almost always broken) is part of the project's nature and thus we are constantly having to make new ones. That being said, the first piece of supply that needs to be tested is the low voltage supply. It is easy to identify due to its large size. An artist's rendition of the supply lies below:



The first step in getting these low voltage supplies ready to be tested is replacing the frontal capacitors that are highlighted on the previous page (50 Micro Farads). You can try to test the low voltage supply without replacing them (there is a possibility that the low voltage supply works with its original capacitors intact), however, I personally have needed to replace these capacitors on 98% of all the supplies that I tested. Thus, I now just replace them immediately to save time. Removing the capacitors is not difficult. One simply needs to heat the solder connecting them to the board and pull them off. A soldering iron is more than adequate to do this task. Once completed, the actual testing can begin.

The method of testing the low voltage supply involves measuring the voltage differences between the Leads. By placing the probes of a voltage meter between the individual Leads, the meter will display the voltage difference between them (assuming it is in the correct mode (for us, this is direct current - DC)).



The diagram above illustrates the pin numbers that will be referenced on the next page. The following is data that is typical of a good power supply. Remember that each low voltage supply is different and a difference of a volt or so will not influence the total performance of the supply. The following chart gives approximate values for the voltage differences between the Leads. If a spot is listed as NA, then its value is not important for the supply.

PINS	1	2	3	4	5	6	7	8	9
1	0	9	NA	NA	NA	NA	NA	NA	NA
2	9	0	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	0	5 to 11	NA	NA	NA	NA	NA
4	NA	NA	5 to 11	0	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	0	NA	NA	5	NA
6	NA	NA	NA	NA	NA	0	NA	17	NA
7	NA	NA	NA	NA	NA	NA	0	NA	NA
8	NA	NA	NA	NA	5	17	NA	0	NA
9	NA	NA	NA	NA	NA	NA	NA	NA	0

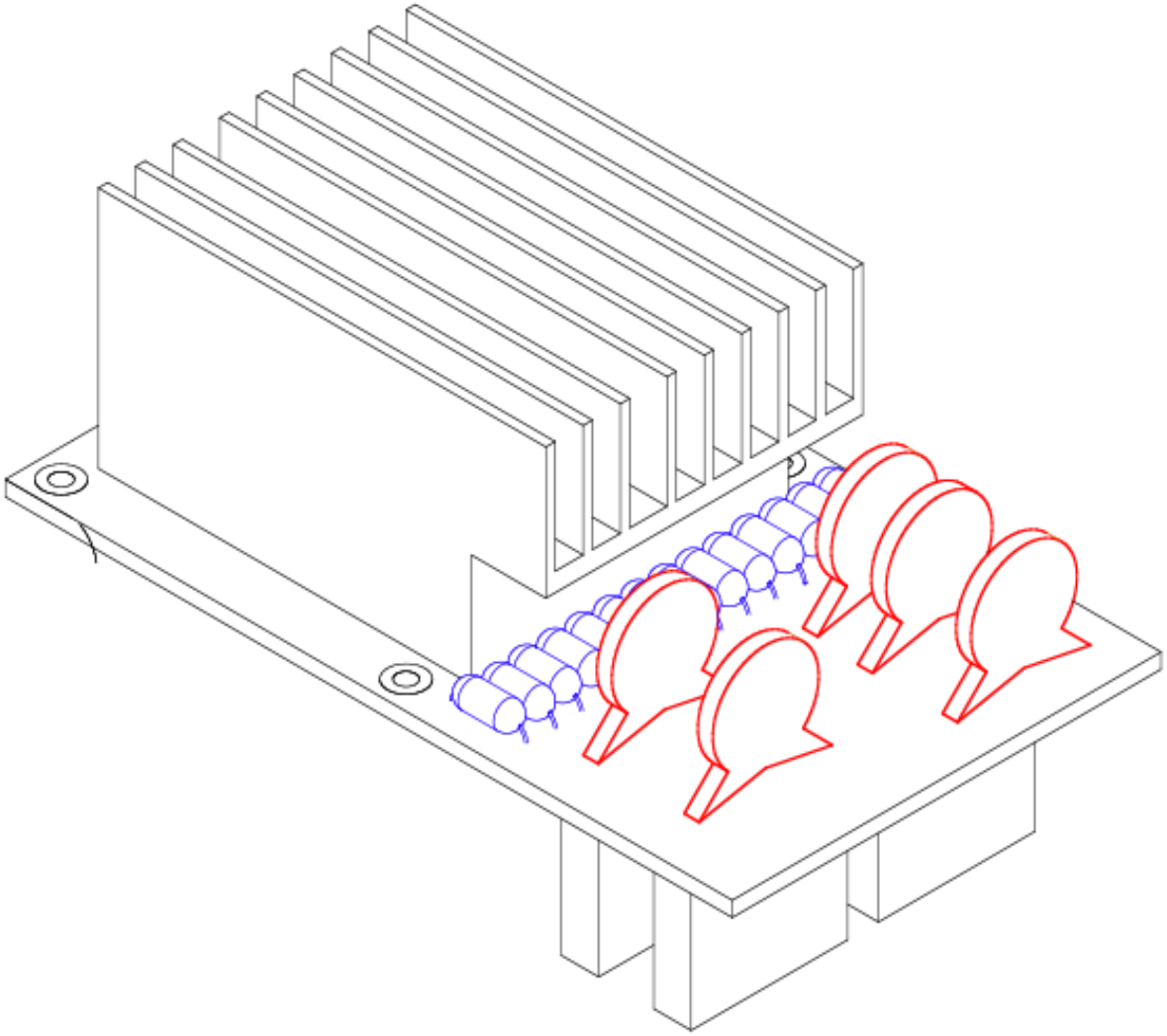
Measurements given in Volts

Once the pins have been tested, all that is left is attaching the final piece to the low voltage supply. This is simply a cable that attaches to the pins. Due to how hard this piece was to draw, we have included a photo. If the pins of the low voltage supply are facing you, then this piece attaches with the green wire on pin 9 and the orange wire on pin 1.

Testing the High Voltage (HV) Pod

This is easily the simplest test that we do in CROP. It is the final piece that requires testing before we begin construction of the supply itself. There are a couple safety issues. It is possible to give yourself one hell of a shock from the high voltage pod if you touch it with your bare hands (I have done this four times, once was very bad). So learn from my mistakes and wear gloves while handling the HV pod and keep it away from conductive objects. That being said, let's get started.

The first step is locating the HV pod. It is the second largest piece in the supply. An image of it is below.

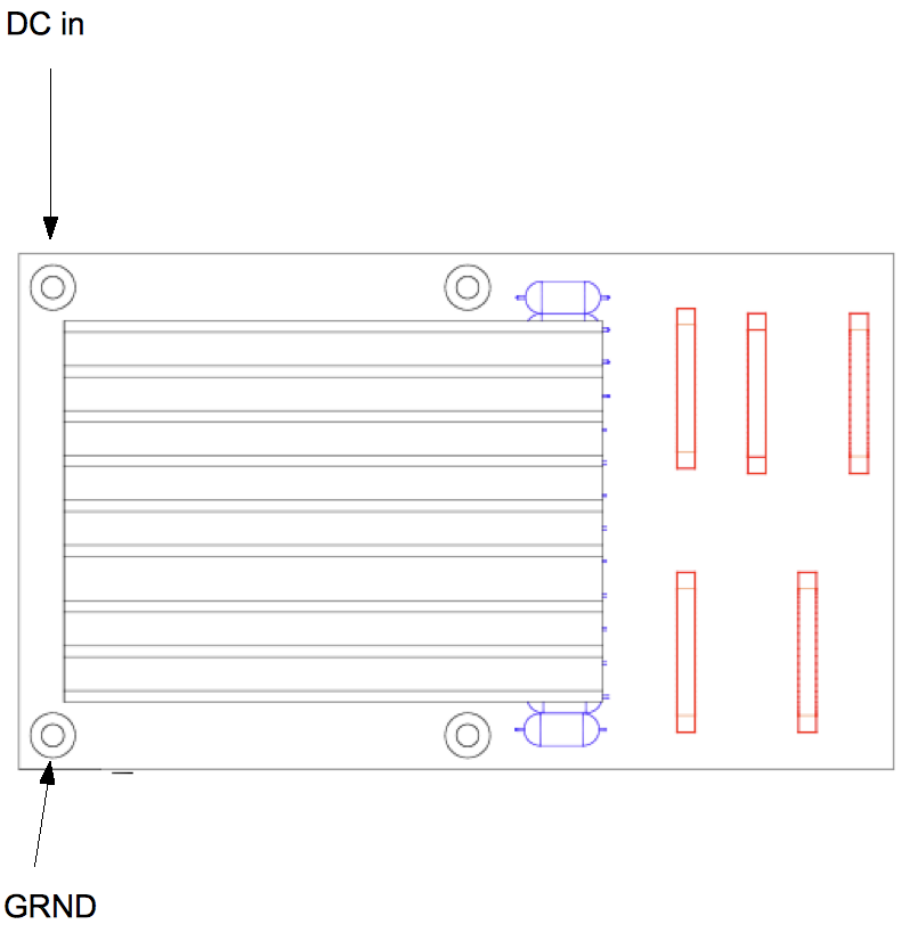


The high voltage pod requires other voltage to power it; it then amplifies that voltage and exports it through the cable connectors at its base. There are two options for providing a voltage to the HV pod. First, it is possible that CROP has a low voltage power supply strictly for this use (we did in my days). This is the easiest method.

However, if such a supply is not at your disposal, then you will use a tested low voltage supply from the previous section.

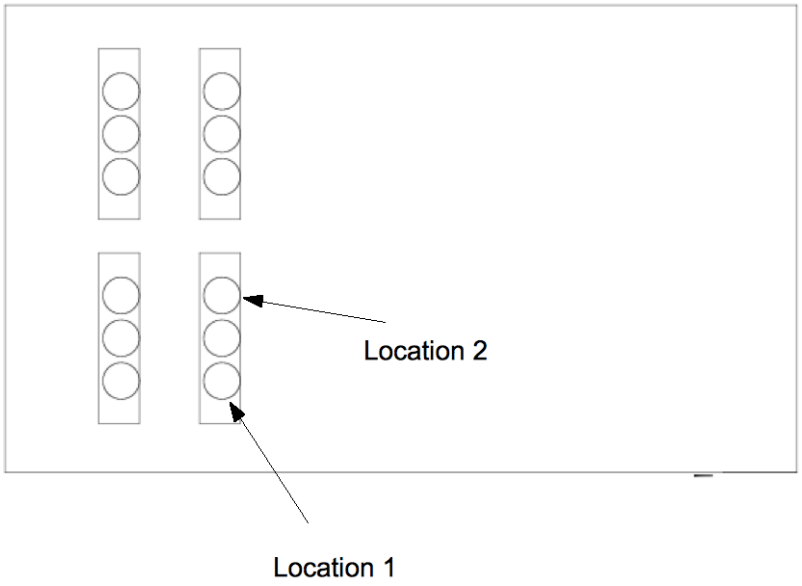
Option 1: If you have a dedicated low voltage power supply, set it at about 5V, then connect the positive output (red) to the connector marked DC in and the negative connector (black) to the opposing site labeled ground (GRND or 0v).

Option 2: If you are using a low voltage supply from the previous section, place the brown wire on DC in, and the black on the GRND.



The next step in the process involves checking the voltage being amplified by the high voltage pod. Doing this requires specialized equipment. The easiest method, that we have found, is to use a voltmeter. In order for the voltmeter not to be destroyed through measuring the extremely large voltages involved, a high-voltage probe needs to be attached. The high voltage probe is easy to identify because it is a very large cone attachment that is roughly eight times the size of a normal voltage probe. An image of one is one the following page.

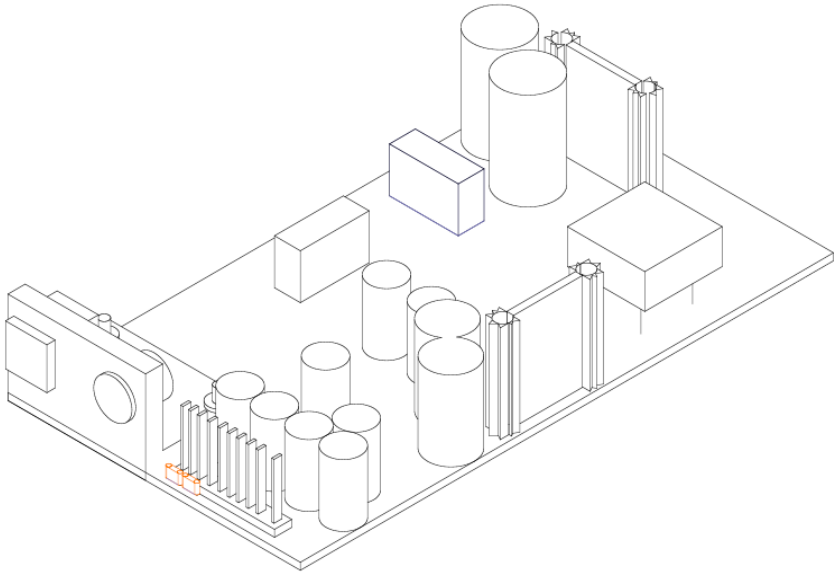
Once the probe is attached, the high voltage can be measured. To do this, place the large probe and the grounding wire in the two outermost holes of the output sockets (the white rectangles with holes in them). The hole in which you place either of the instruments does not matter. If you have it reversed, the voltage will simply be read as negative (we are interested in the absolute value). The high voltage probe will divide the actual voltage by 1000 before it is displayed on the meter (display says 1V there is really 1000V emanating from the supply). A reading of over .9 V from the meter means that the power supply is working properly.



Soldering Power Supply Parts

Parts and descriptions:

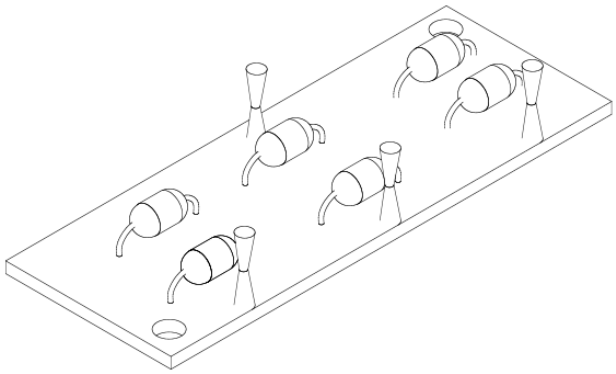
1. **Low Voltage Supply (LVS)** – large blue/black board with many capacitors.



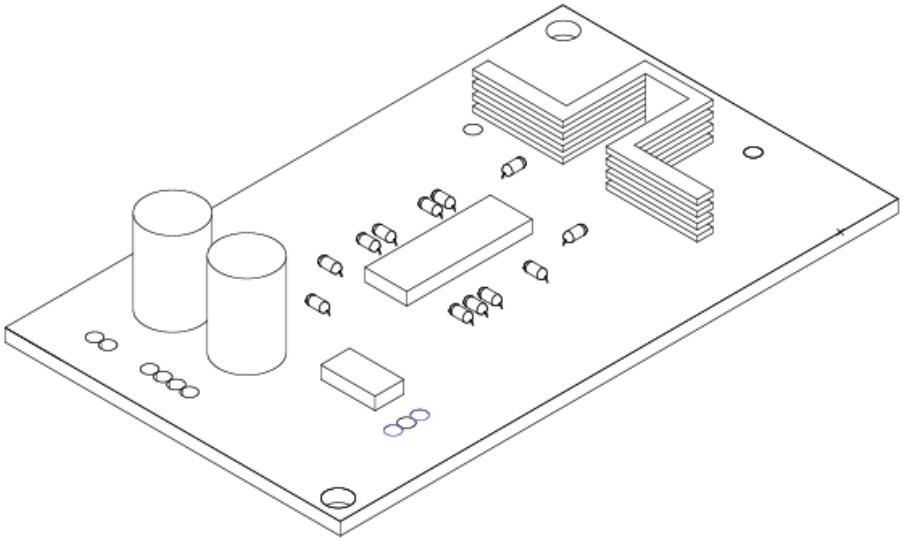
Must have attached:

   a. Power cord with switch
   b. Black clip with colored wires. Strip gray surrounding plastic with a razor blade.

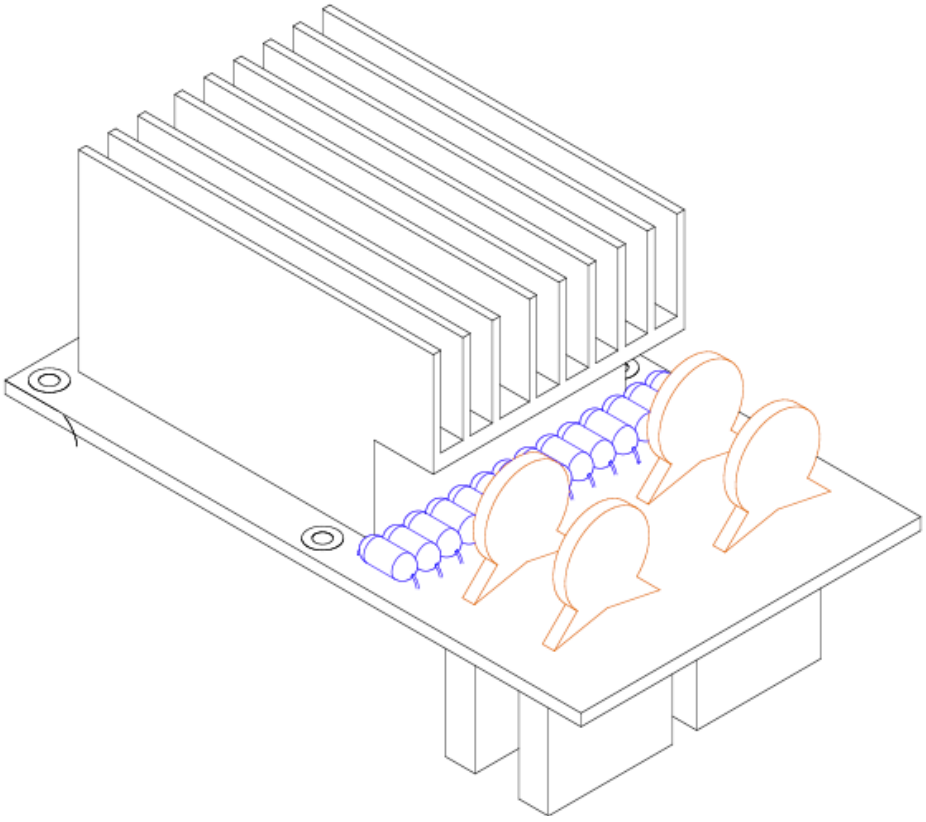
2. **Tan Resistor board (RB)** – small board with several large blue resistors. May already be attached to LVS. May have a pink ground ‘pin’ attached.



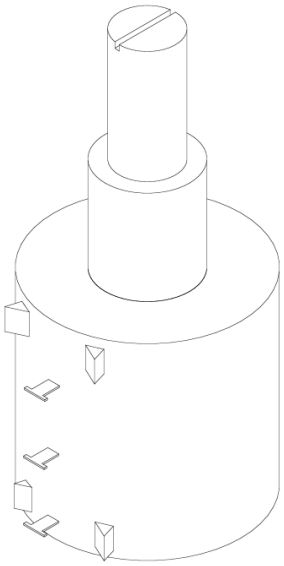
3. **Voltage Divider (VD) [aka Board We Don't Know What It Does]** – Comes prepackaged with several colored wires extending off.



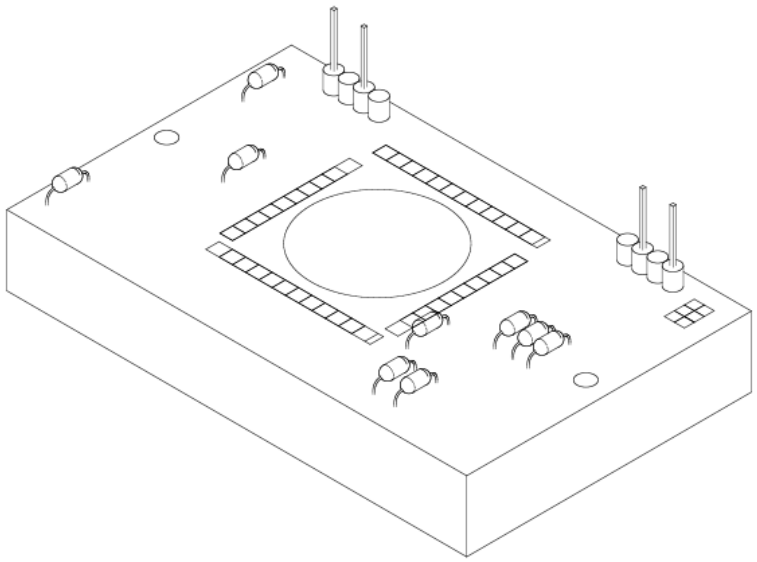
4. **High Voltage Supply (HVS) –** Green board with orange capacitors and black metal ridged object



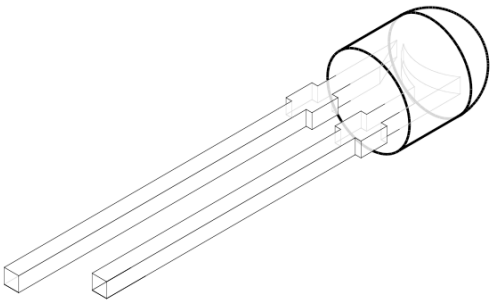
5. **Potentiometer (P)** – Blue adjustable potentiometer with three metal terminals.



6. **LCD Display (LCD)** – Green circuit board with black case and display. Be sure to have an outside holder with screws as well.
   a. Two terminals labeled “P1” on the back should NOT be soldered together.



7. **Light Emitting Diode (LED) –** Small clear light (turns red when on).



8. **Resistor (R)** – Used to lower voltage to LED.

Hints/Tips:

1. Solder everything together before putting into power supply metal case.
2. Twisting and braiding wires together may avoid confusion/entanglement. Zip ties are also helpful for this.
3. The colored wires from the LVS do not need to be very long. They can be clipped to about 6 to 8 inches without detriment.
4. Generally, things may be soldered together in any order.
5. Be sure all parts work (especially LVS and HVS) before soldering. This will save you a lot of grief!

Careful when turning on and off!!

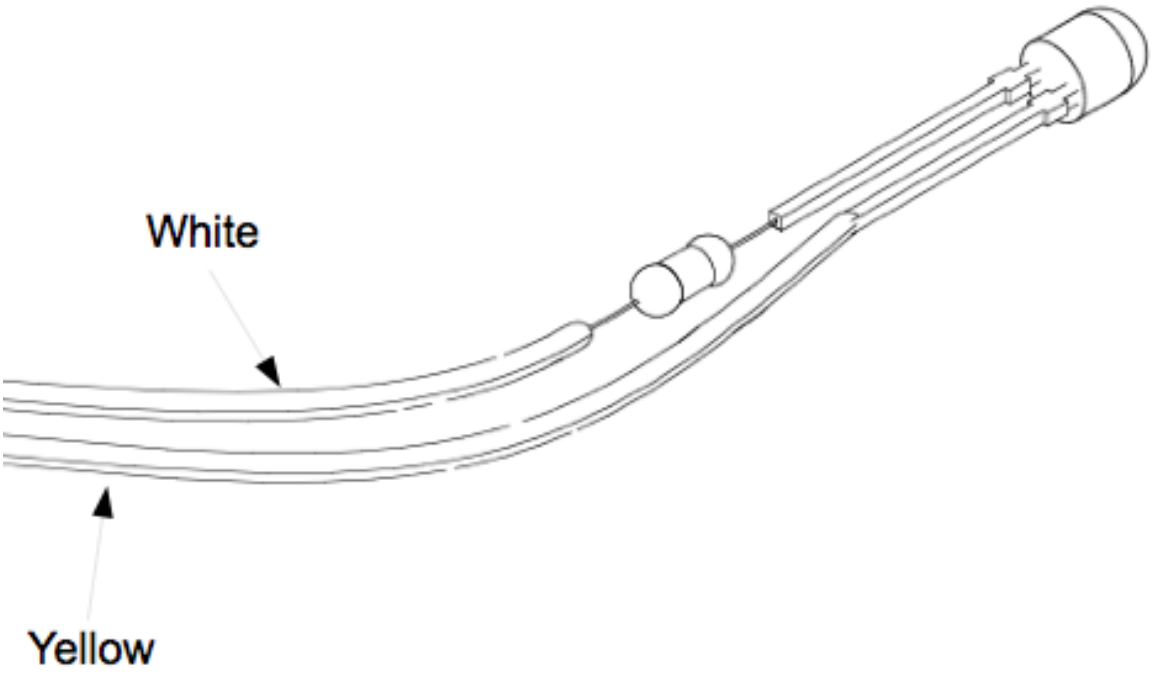
Place on a non-conductive surface, wait several moments for capacitors to discharge, and handle with a glove or cloth!!

Wiring

Wires from the Low Voltage Supply

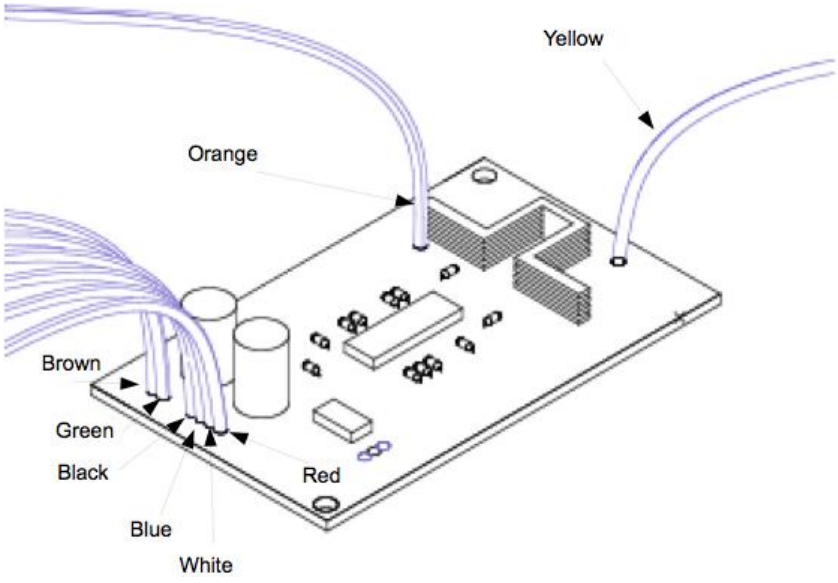
White & Yellow: [R] & [LED]

1. Connect in series with **[R]** and **[LED]**. As in, connect white wire to resistor; resistor to long lead of LED; and other LED lead to the yellow wire.
   a. R can be on either lead of LED.
   b. Cover in electrical tape or liquid electrical tape to avoid exposed wiring.



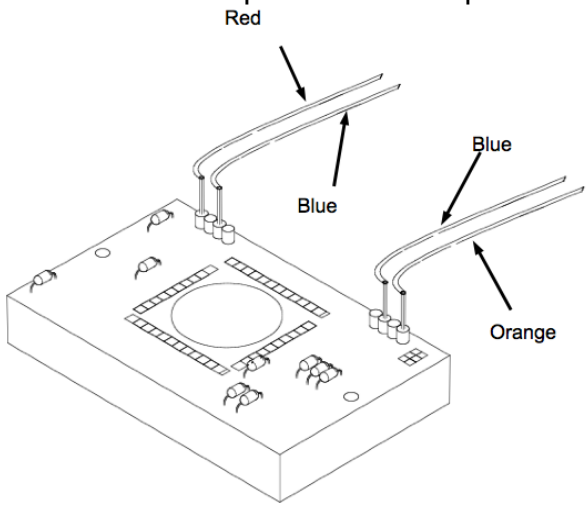
Black, Red, & Brown: [VD]

1. These wires go in spots close to the two large capacitors. Strip ends of wires and solder into each hole.
   a. Red goes to hole labeled “V-“
   b. Black goes to hole labeled “GND”
   c. Brown goes to hole labeled “V+”



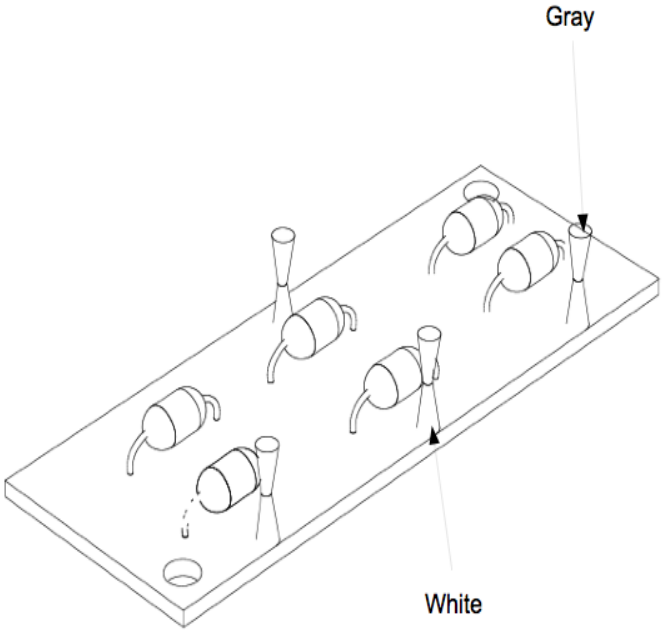
***Orange* & *Blue*: [LCD]**

1. These go to the LCD pins labeled “9V”. These are below the blue/white adjusting dial.
   a. Orange goes to the outside pin.
   b. Blue goes to the inside pin.
   c. Cover exposed metal with liquid electrical tape.



Gray & White: [RB]

1. These should already be attached to the tan resistor board.
   a. White goes to middle metal pin of three on one side.
   b. Gray goes to end pin of three, the one with the hole farthest from it and resistors are closest.



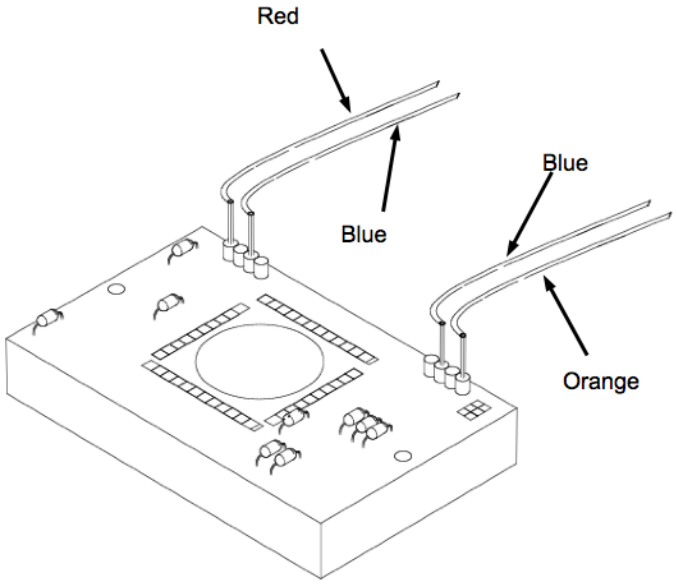
***Green* & Black:**

1. These wires do not connect to anything. Trim and make sure to leave no wire exposed.

Wires from Voltage Divider:

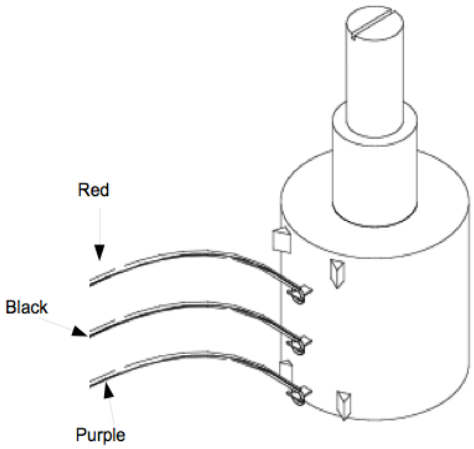
***Red* & *Blue*: [LCD]**

1. These go to the LCD similar to previous Orange/Blue wires from LVS, but on the pins labeled IN- and IN+.
   a. Red goes to the outside pin.
   b. Blue goes to the inside pin.
   c. Cover with liquid electrical tape.



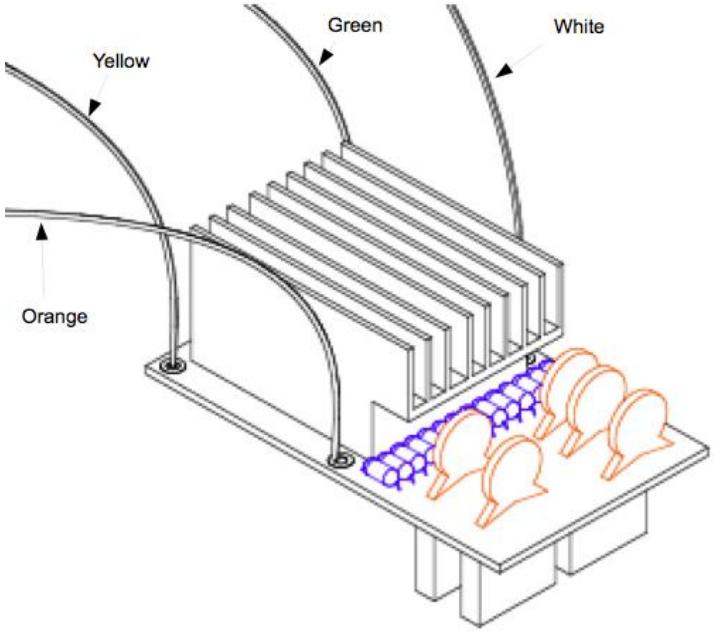
***Black*, *Purple*, & *Red*: [P]**

1. These go to the metal terminals on the potentiometer.
   a. Red goes to the pin closest to the adjust knob.
   b. Black goes to the center pin.
   c. Purple goes to the farthest pin, closest to the base.



Green, White, Orange, & Yellow: [HVS]

1. Solder onto the rings below the black ridged object.
   a. Yellow to circle labeled “GND”
   b. Green to “DC IN”
   c. Orange to “SENSE”
   d. White to unlabeled circle near copper coil.



Testing:

1. Place everything on a non-conductive surface, such as a book.

2. Plug LVS into wall socket, flip switch to turn on.
   a. Be sure LED lights up! If not, the white and yellow wires may be switched!

3. Turn potentiometer until LCD displays 1000 Volts.

4. Using a high voltage probe and a voltmeter, test voltage from HVS.
   a. Any two opposite pins will work. Touch each terminal of the high voltage probe to a metal pin inside the plastic clips: [x O x]

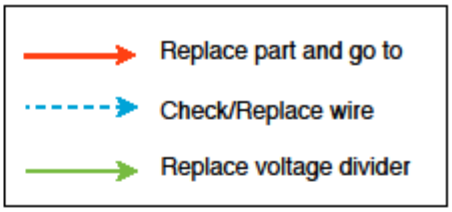
b. If voltage reads zero, then something doesn't work or a connection is bad.

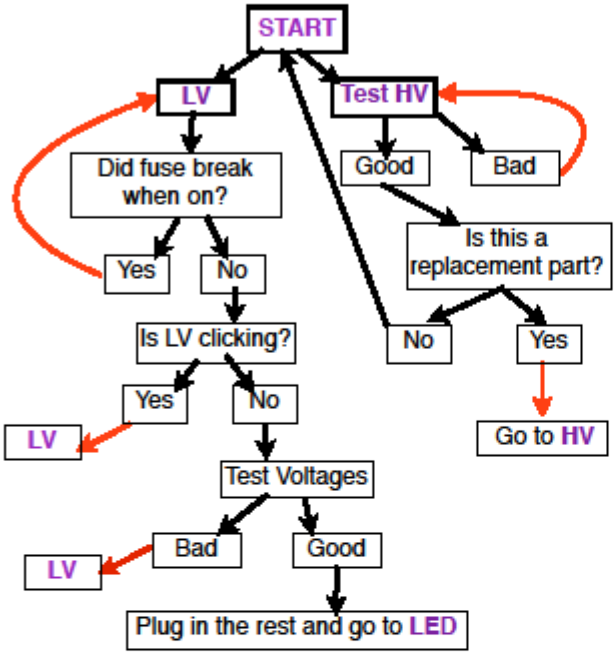
5. Adjust the LCD display until it reads the actual voltage.
   a. Use a screwdriver, find the small twist-adjust knob (blue and white) on the back side of the LCD.

6. Change potentiometer until LCD displays 1350V.
   a. Repeat testing with voltmeter and adjusting LCD.

7. Repeat with 1000V to check consistency. Small deviations (about 3-5V) are okay. The smaller, the better.

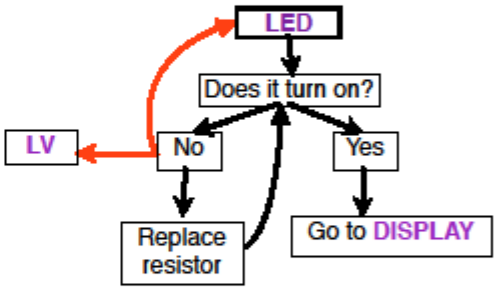
Power Supply Testing and Troubleshooting

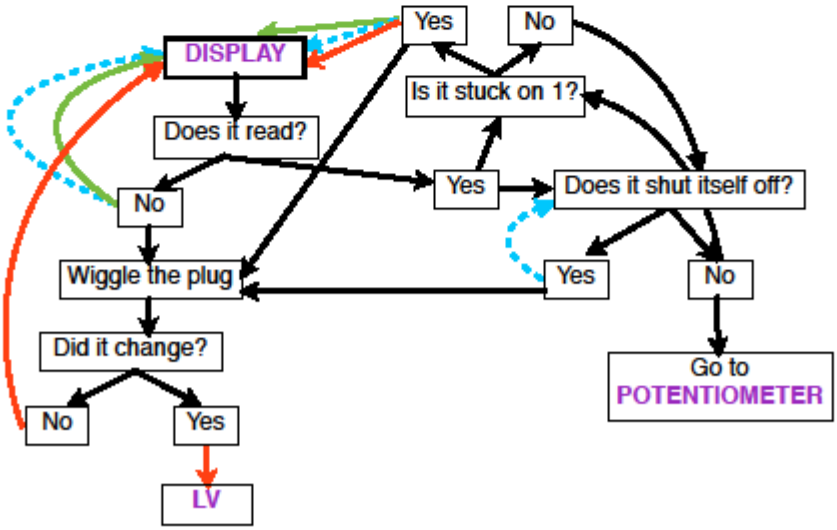


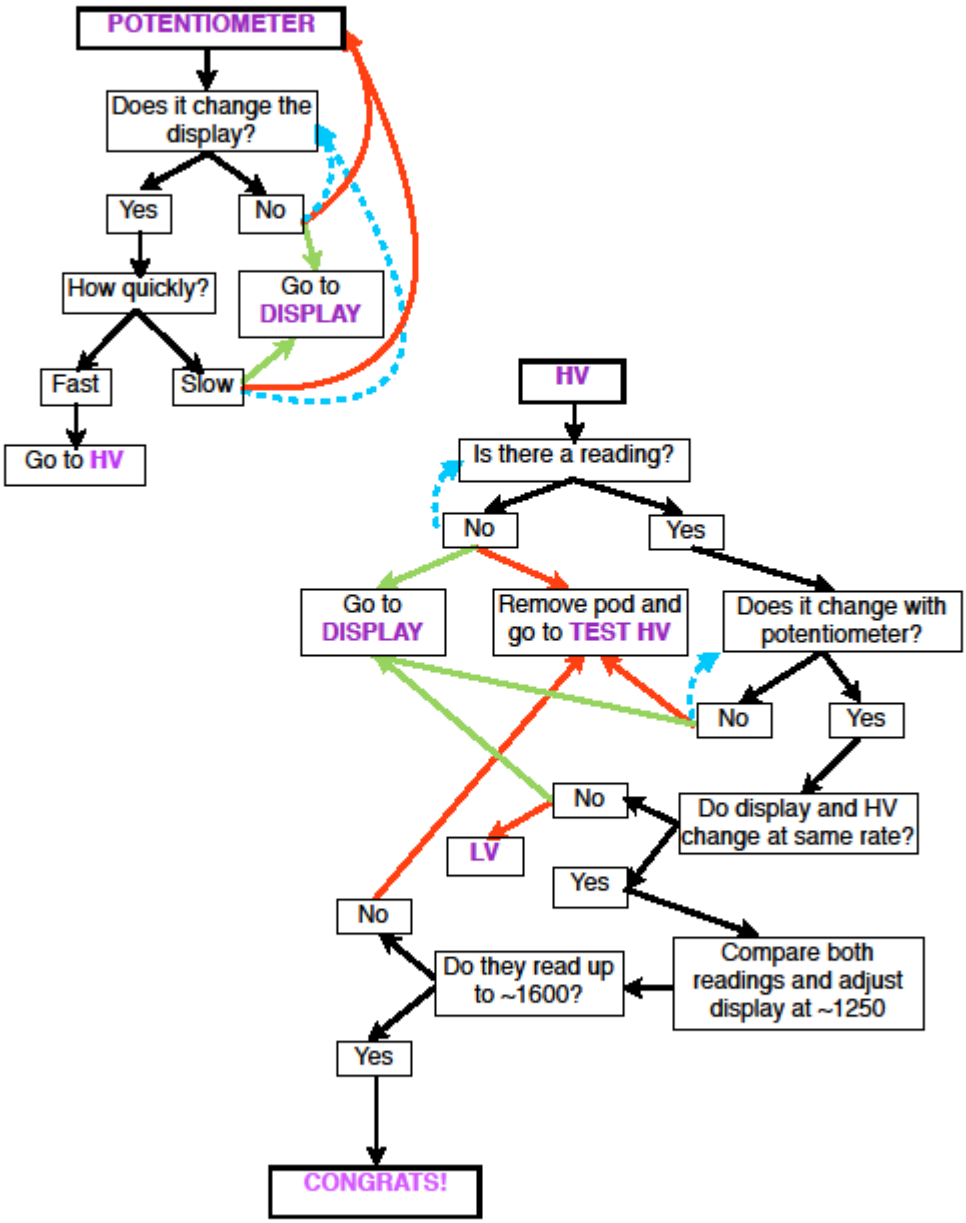


Tips for safety and reliability:

- cover connection of wires with heat shrink
- if soldering wire into port, use minimal exposed wire
- don't let solder cross two ports
- do not solder if part is turned on
- turn off whole assembly if there is smell of burned electronics
- make sure all capacitors are there and secure






POTENTIOMETER
Does it change the display?
Yes
No
How quickly?
Go to DISPLAY
Fast
Slow
Go to HV
HV
Is there a reading?
No
Yes
Go to DISPLAY
Remove pod and go to TEST HV
Does it change with potentiometer?
No
Yes
No
Do display and HV change at same rate?
LV
Yes
No
Do they read up to ~1600?
Compare both readings and adjust display at ~1250
Yes
CONGRATS!