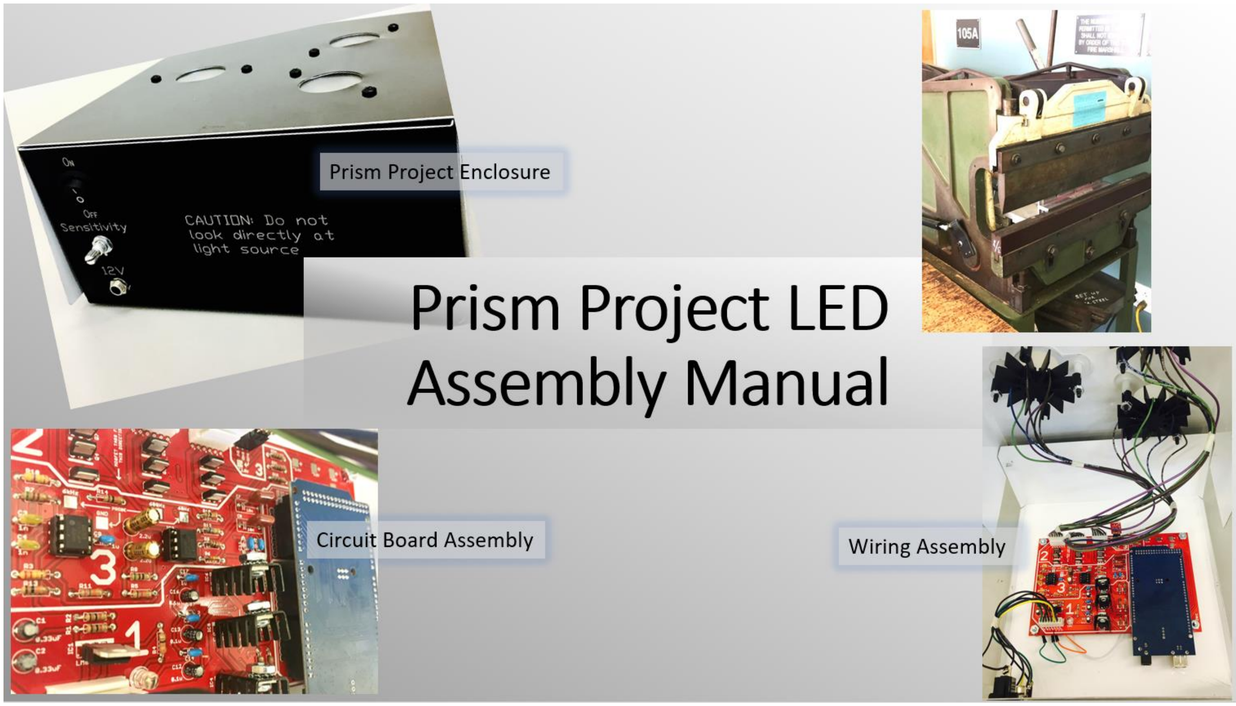

Basic Electronics Manufacturing

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Contents

Overview

This guide includes step-by-step instructions for assembly for your Prism LED project. **<u>READ THIS ENTIRE GUIDE</u> CAREFULLY BEFORE BEGINNING.**

Before components are soldered, the empty board is called a Printed Wiring Board (PWB). After assembly, it is called a Printed Circuit Board (PCB). Assembly of the PWB for this project is segmented into several parts or regions; be sure to <u>carefully</u> follow the instructions for each step. This project offers some complexity and opportunities to practice several processes - following these instructions carefully will help *you* be successful. Troubleshooting is **<u>much</u>** simpler when this project is constructed step by step.

Some common terms used in PWB design and assembly will be bolded and (italicized), these are further defined in the Glossary at the end of this guide.

PCB Assembly

Step 0. Inspect your PWB (shown in Figure 1). Do not be alarmed if the color of your board is different than shown. Write your first initial and last name on the top side of your board with indelible ink (Sharpie pen).

The heavy white outlines each contain a number corresponding to each step and region highlighted in this guide. Solder parts inside the region corresponding to the current step <u>only</u>. The end of each step includes testing points to help ensure everything is working correctly up to that point. This provides opportunities for feedback on your work and simplifies troubleshooting greatly.

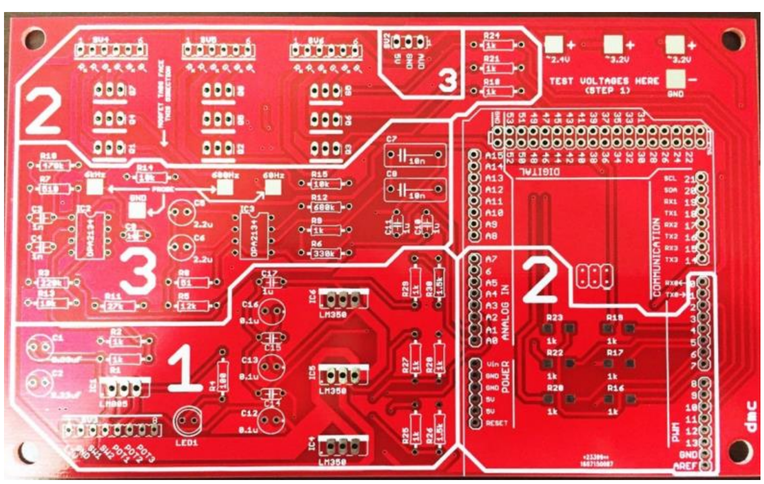

Figure 1: Top side of the PWB. Components are placed on this side, and the leads poke out from the bottom (opposite) side. Note the regions that correspond to the steps in this guide MUST be assembled in order.

The back side of the PWB also has outlines and numbers that mirror the top; you should only solder on the back side of the board (except the six surface mount resistors in Region 2).

STEP 1A. Solder components inside region 1.

READ THE SOLDERING TIPS AND EVALUATION CRITERIA (AT THE END OF THIS SECTION) BEFORE YOU BEGIN SOLDERING.

In Region 1, you will solder 9 resistors, 8 capacitors, 4 voltage regulators, 1 LED and one 8-pin male header. Once soldered, **do not desolder leads without guidance from your instructor – this risks damage to the PWB.** White ink markings on the top side show which components to place in each position. The markings include reference designators (R1, C2, IC3, etc.), values (1k, 0.1uF, etc.), part numbers (LM350, LED) and/or polarities (+ sign) to guide assembly. **Note:** Resistor R4 controls the brightness of the on-board LED. 1K resistor is supplied, but you could change this value to adjust brightness**.**

Resistor values are marked at each resistor location. Resistors have colored lines indicating their resistance values in accordance with standard color codes. Use a resistor color code chart or a multimeter to determine the correct resistors to install. **Note:** Resistors are not polarized, but for ease of inspection (and maximum score) you must orient them with their color bands reading the resistor value left-to-right relative to the text on the PWB. In other words, tolerance bands must be on the right side.

Some capacitors are ***polarized*** and must be installed in the correct orientation. Within region 1, only C1, C2, C12, C13, and C16 are polarized. Each of their ***footprints*** have a small plus sign (+) marked on the board, designating where the *positive lead* of the capacitor should be soldered.

- *Note: Not all capacitors are polarized. A polarized capacitor is usually marked with a negative stripe running along the side of it. The lead closest to this side of the capacitor means that this lead is negative (cathode). Most capacitors have two leads; the longer lead is the positive lead (anode).*

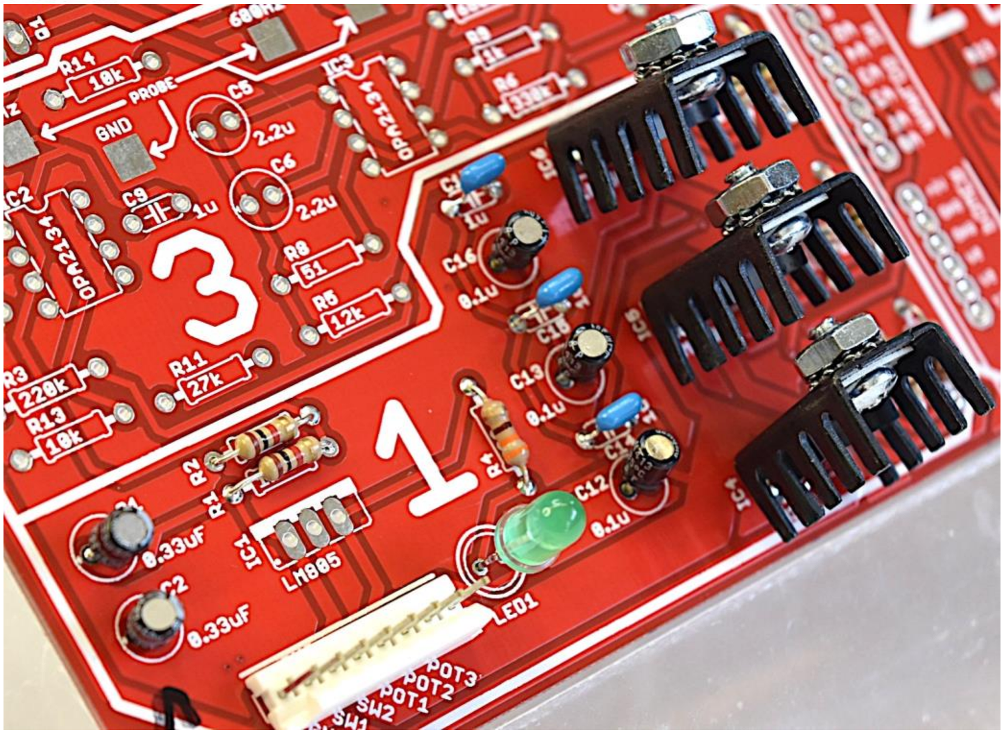

Figure 2: Nearly all components mounted to the PWB corresponding to Step 1A. Note: LM805 regulator not installed yet in photo.

Note the white header is installed with the clip on the outside of the board. This provides easier access to disconnecting the wire loom from the board in the future.

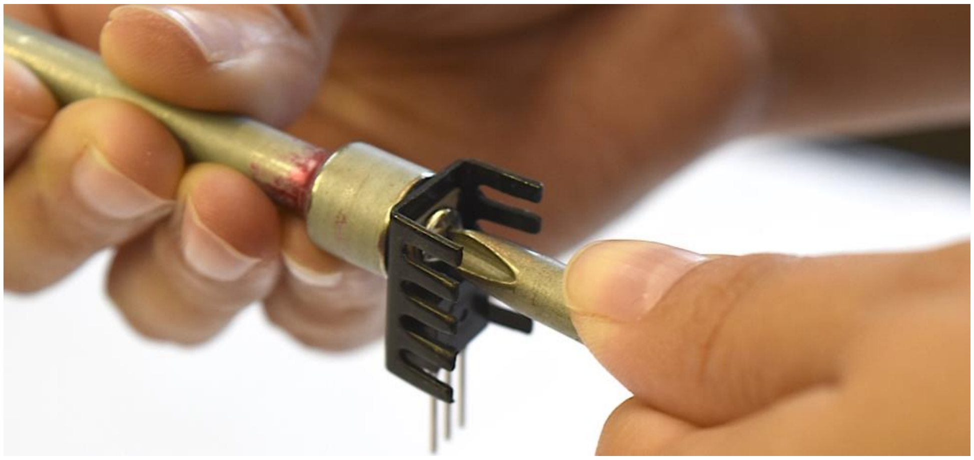

Figure 3: Attach LM350 regulator heat sinks with star lock washer under nut before soldering (as shown here with Phillips screw driver and yellow-handle #6 nut driver or pliers holding nut).

It is good practice to install components with their bodies close to the PWB surface. However, avoid applying excessive stress on the component body which could cause damage. Always bend resistor and capacitor leads carefully and push gently during insertion into PWB through-holes. For aesthetics, resistors must be **flush within 1 mm of the PWB** surface for maximum credit. Other components should be reasonably close. Regulators have a slightly wider shoulder in their leads - so they <u>do</u> <u>not</u> rest flush against the PWB. Once positioned on the PWB, bend the leads or use masking tape to secure in position while soldering from the other side. Connectors, voltage regulators and other types of components may have polarities – look for the board markings or images in the figures to ensure proper installation.

Your kit contains three heat sinks and associated hardware to attach them to LM350 regulators which power the 3 watt RGB LEDs (See figure 3). Kit hardware includes a set of three #6-32 x ¼ inch screws, star lock washers and #6-32 hex nuts. Because of limited tool access it is strongly recommended to **attach the heat sinks before** soldering regulators. LM7805 do not require heat sinks.

Soldering Tips

- Apply solder only to the lead/pad interface after heating the joint sufficiently to melt solder to both the lead and the pad.
- Use the <u>minimum</u> <u>amount</u> <u>necessary</u> to apply solder all around the lead/pad interface. Optimally, contour must be concave and smoothly join with the lead and pad.

IMPORTANT: Trim all component leads to 1-2 mm above solder joint as you go to get them out of the way while soldering. You must trim the leads to lengths of 1-2 mm above solder joint before testing (and evaluation) to avoid shorts and for maximum points.

Evaluation of your PCB – **Important!**

There are workmanship criteria that <u>must</u> be followed throughout this project for maximum quality, reliability **(and points!)**. You will complete a self-evaluation of your PCB using a form with grading criteria for various categories. The form is due with your PCB no later than week 8 of the quarter. **PCB Self-Evaluation Form is available in the lab and on PolyLearn.** You <u>must</u> review this form before you complete your PCB to achieve maximum target conditions in your work **(and your score!). Please look over the form as soon as you begin soldering so that you know what the goals are!**

Questions 1A:

1. Soldering only components in Region 1 and testing before proceeding helps in what way(s)?
2. Capacitors that are polarized have two features that indicate polarity. What are they?
3. Should heat sinks be attached to LM350 regulators before or after soldering?
4. How close or flush to the PWB surface must resistor bodies be for maximum credit?
5. Orient resistors with their tolerance bands on the right because of which reasons?
6. Do regulators and capacitors have to be flush with the PWB surface like resistors?
7. What are the suggested tools for removing flux residue from your PWB?
8. (T/F) Always wear safety glasses when removing flux residue by any method?

STEP 1B: Attaching wires to panel mount components

In this step, you will solder and crimp seven wires to the panel mount components and attach to the 8-position header connector. These connections provide power, sensitivity adjustment and on/off switching for your system.

First, measure and cut seven 6 to 8-inch length 22 or 24 gauge wires. The wire colors here do not matter. Strip $^1/_8$ inch of insulation from one end of each wire to prepare for crimping. Try to avoid cutting any copper wire strands when stripping insulation. Your instructor or TA can demonstrate wire stripping and crimping. Example of inserted crimped wires in the header is as shown in Figure 4. Note: See Appendix 1 for crimping details.

This Prism LED system has three external components mounted on the chassis and wired to the PWB: the DC Power Jack, On/Off Switch and sensitivity-control Potentiometer. Each has terminal lugs with holes for feeding wire through to attach by soldering. For strength, wire must be fed through the lug holes (if holes are present) and/or wrapped around the terminal before soldering. To achieve this, strip approximately $^1/_4$ to $^3/_8$ inch of insulation from the other wire ends opposite the crimps and feed through the lugs and/or bend around terminals. Apply solder to the wire/lug interface to encapsulate all wire strands completely. Excess wire strands not encapsulated in solder must be trimmed off. Wires must attach lugs at 180(to avoid interference. Figure 6 and Figure 7 show target results. Note above 'musts' = maximum points for wire/lug solder joint evaluation.

You may use any colored wiring that you wish, but be sure that the connections match with the physical components. Note that the far-left slot is unused. Be sure to thoroughly examine Figure 4 and Figure 5 to understand how the components are wired before proceeding.

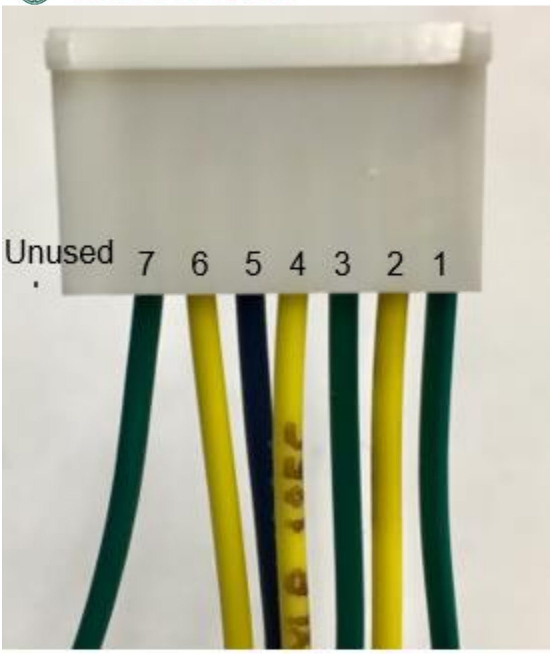

Figure 4: The 8-position header slots are faced down to illustrate this wiring

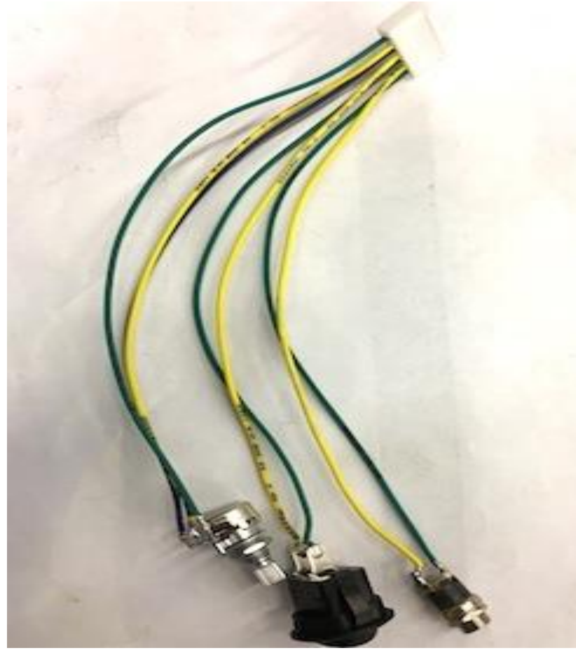

Figure 5: Approximately 6-8 inch wires are soldered at the panel component and crimped to the header.

Figure 6 and Figure 7 shows the wiring for the DC power jack - <u>this is **critical**</u>! The red wire (positive 12V lead) solders to the outer ***lug,*** and the black wire (negative GND lead) solders to the inner lug. In this case, the **outer lug sits on top of the inner lug**. If your jack has a third extra lug on the side, <u>do not wire</u> to this lug.

<u>To summarize the correct wiring of the power jack:</u>

The positive lead (outer lug stacks on top of inner lug) is crimped and connected to header slot 1 (refer to Figure 4). The negative lead (inner lug) is crimped and connected to header slot 2 (refer to Figure 4.

Figure 6: Wiring of the DC jack is critical. The red wire shown (outer lug) connects to slot 1 (12V position) of the 8-position header. The black wire (inner lug) connects to slot 2 (Gnd position) of the 8-position header.

Figure 7: There may be a third lug on the side of your jack as shown. If so, do not use this extra lug.

In Figure 8, the potentiometer lugs are oriented faced ‘up’. Tracing the wires, in Figure 4, the potentiometer leads are wired as shown in Figure 8 and crimped to slots 5, 6, and 7 of the 8-position header.

Figure 8: When soldering wire to the potentiometer, ensure that the lugs are facing up. Refer to Figure 4 to see wiring. Note: Solder encapsulates all wire strands and wiring is oriented 180 to the terminal.

The final panel-mount hardware installation step is the switch module. Note that here we can actually wire things arbitrarily (see Figure 9)! That is, it doesn’t matter which wire you connect to which lug as long as they connect to header slots 3 and 4. **Note:** Switch must eventually be installed in chassis from the outside. This may be accomplished by simply de-soldering the switch before final chassis assembly and then re-soldering after installation.

Figure 9: The color of the wire used for the switch does not matter, as long as wires connect to slots 3 and 4. **Note**: The wires are soldered at approximately 180 degrees (parallel) to the solder lug axis.

STEP 1C.: Electrical Test

In this step, you will electrically test all of the components assembled in Region 1. It is very important to verify that the assembled components are working together properly at this point. This will provide feedback on the integrity of the solder joints, crimps and components and simplify troubleshooting significantly if anything is awry.

- Connect the 8-position, crimped header from your wire assembly to its mating 8-pin connector in Region 1 on the PWB. Ensure the pins and slots are aligned. Try rocking the connector back and forth slightly to help plug or unplug connector as necessary.
- Connect the 12V power supply to your DC power jack (DO NOT CONNECT TO THE ARDUINO DIRECTLY), and switch on. If everything is working correctly, **the red LED should power on**. If the LED does not power on, turn off the switch and disconnect the power supply. See troubleshooting tips for this step later in these instructions to determine the cause and possible corrective action. **If you cannot find the cause, ask a TA or instructor for assistance.**
- Use a digital ***multimeter*** set to DC voltage for the next step; multimeter models may differ, but the symbol indicating the DC voltage setting is standard (see Figure 10).

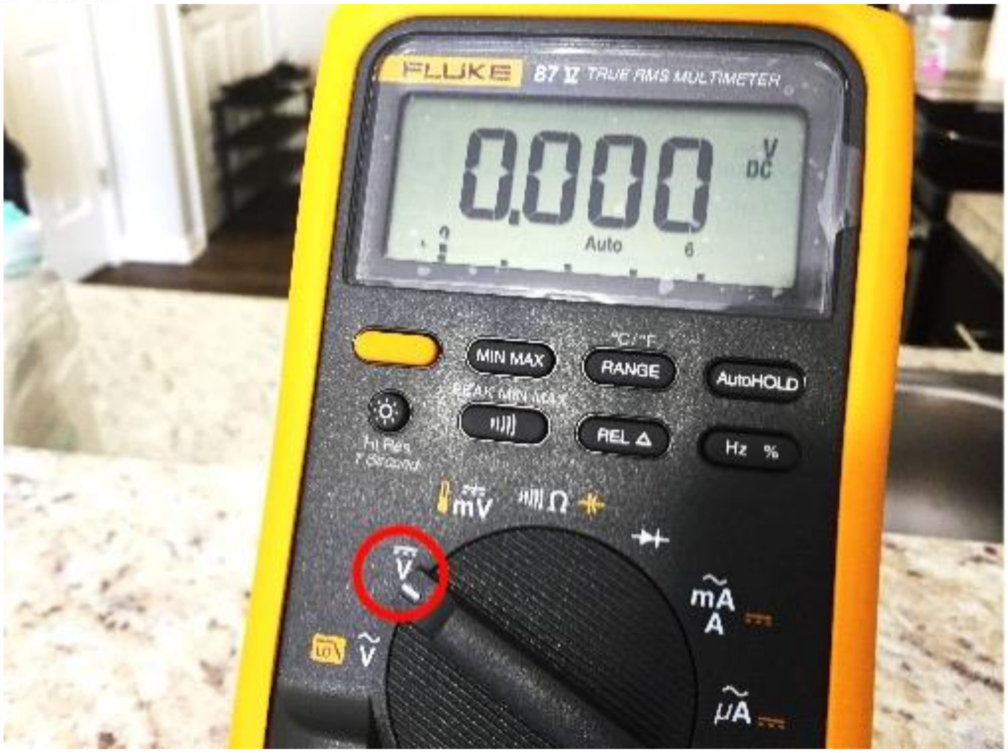

Figure 10: Digital multimeter set to DC voltage setting

Using the digital multimeter, measure the voltages at each test pad located at the upper right corner of the PWB. Hold the black lead to the pad marked “GND”. The red lead should touch each of the pads marked with the plus sign (+) as shown in figure 9.
Confirm that:

- Left pad outputs approximately **2.4~3V** (Figure 11 shows measuring of the left pad).
- Center and right pads output approximately **3.2~4V**.
- Microphone module pad should read approximately **2.5V**. (**<u>This only works after the microphone is installed</u>**).

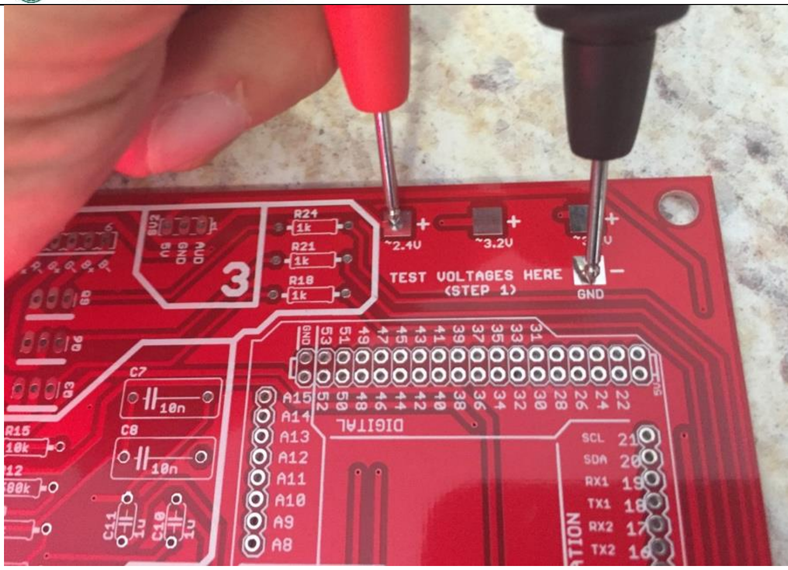

Figure 11: Test pads are located at the top right of the PWB. (Note: Microphone test pad is <u>not</u> shown here).

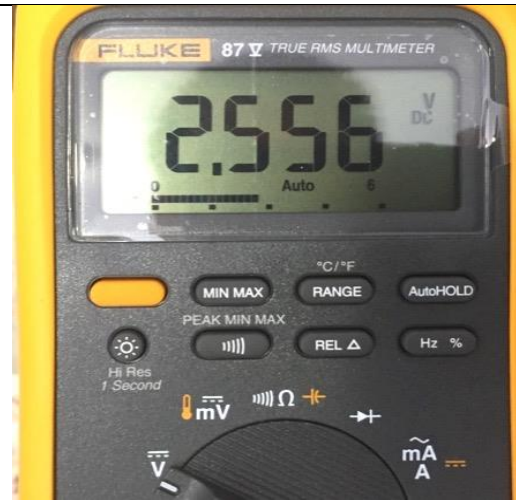

Figure 12: Check that each pad outputs the approximate voltage indicated on the PWB.

If the voltages cannot be verified according to step 1C, refer to the troubleshooting section at the end of these instructions. **If you need further assistance, ask a TA or your instructor.**

STEP 2A. : Solder Surface Mount Devices

Due to their small size, the 1K surface mount (SM) resistors may not be included in your kit. **Your instructor or TA will provide you with the correct SM resistors.** Solder the six SM resistors located near the bottom right corner of the board (R16, R17, R19, R20, R22, R23). (See Figure 13).

Side Note: SM components are designed for modern, automated circuit assembly methods and tools called pick and place machines. They are inherently more challenging to work with by hand. (If you’re successful, congratulations! Yes, but,…) These six resistors are actually ten times larger than some of the components in your phone or computer, but were included to give you an idea of how SM components look and feel.

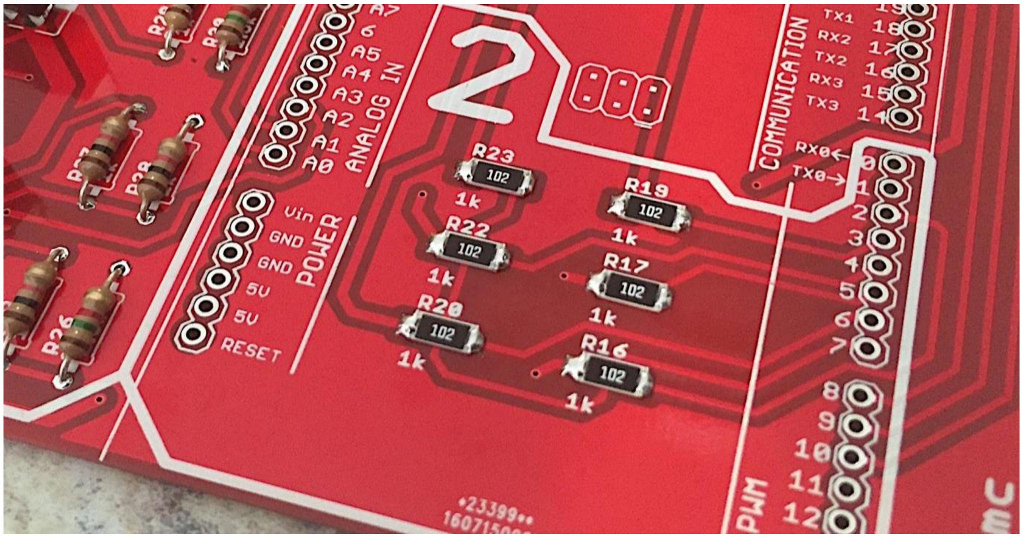

Figure 13: Surface mount resistors mounted at the bottom right corner of the board.

Surface mount device (SMD) soldering Tips:

- Start by applying a **TINY** amount of solder on **only one** of the pads. Using a small pair of tweezers, move the resistor into place while heating the pre-soldered pad. Once the resistor is in place, remove the soldering iron from the pad, but continue to hold the resistor in place until cool. Finish by soldering the other end of the resistor to the other pad. **ASK INSTRUCTOR OR TA FOR A DEMONSTRATION IF YOU ARE UNSURE ABOUT HOW TO DO THIS**.
- The resistors are rather small, and sometimes they might flip upside down (which is completely beyond your control). For practice, try picking them up with the tweezers and dropping them from a 1 inch height until you get a feel for how they behave.
- **Watch this video** - How to solder small SMD resistors: https://www.youtube.com/watch?v=lrDyUj7ZfVI (Also on Polylearn).

STEP 2B:. Solder the male headers to the PWB in region 2.

Male headers must engage with the Arduino microcontroller**. ENSURE THAT THE HEADERS ARE FLUSH WITH THE BOARD**. Review figures Figure 14 and Figure 15 before starting to better understand what the target condition is for assembly of male header pins. The attachment tips provided may be helpful.

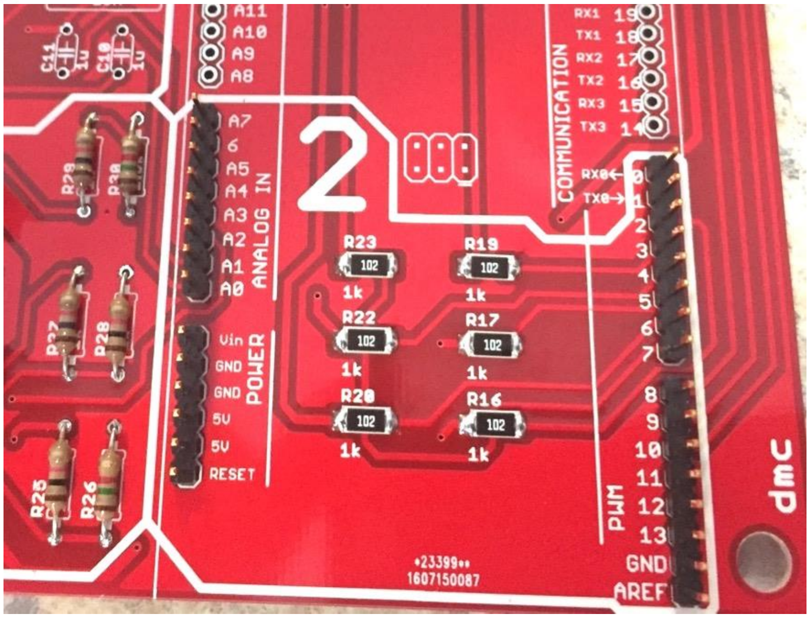

Figure 14: Male headers are mounted only inside Region 2. They **MUST** be mounted with their bases **FLUSH** with the PWB surface (see Figure 15).

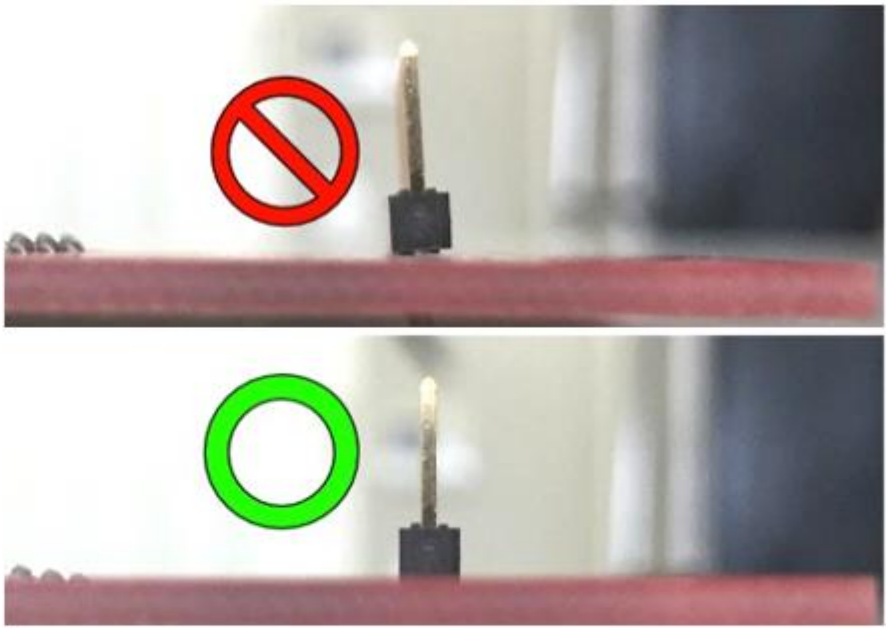

Figure 15: Examples of a non-flush (top) and flush (bottom) header. Pins must be perpendicular to the PWB to mate correctly with Arduino microcontroller.

Multi-pin header attachment tips:

- Try securing the headers with tape before soldering. Make sure that the headers are flush before soldering! Ensure they don't move when turning over to solder.
- **DO NOT** apply downward pressure to the header pins while you are soldering - this can cause the pins to shift out of place.

- **DO NOT** heat the pins excessively – allow time to cool, overheating will increase the chances that the pins will shift out of place.
- **Alternatively**, plug the header pins into the Arduino board and use the Arduino to hold the headers in position during soldering.

STEP 2C: Solder Remaining Components in Region 2.

In this step, solder the remaining components in region 2 in the top-left area of the PWB. Make certain that the nine transistors are facing the correct direction! (See Figures 12 and 15)

STEP 2D: Mounting the LEDs

SEE APPENDIX 2 for LED soldering, crimping, mounting and testing details.

STEP 2E. Uploading Prism code to your Arduino

After assembling and testing LEDs with a multimeter, we must test that the LEDs are also working properly via communication with the Arduino. There is an LED test program built into the Prism code you will be provided. Go to PolyLearn **for your lab** under **Week 1** for Arduino code instructions. It is recommended that you load your code in the 156 lab per the instructions.

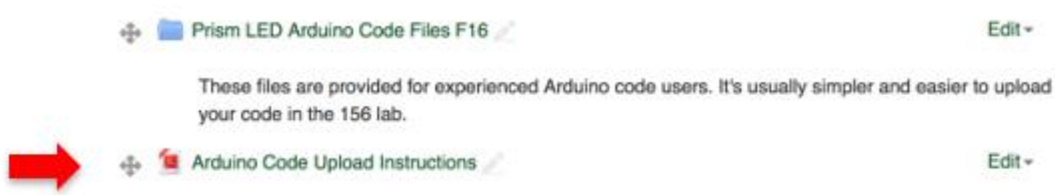

Figure 16: Arduino code upload instructions located in PolyLearn

STEP 2F. Connecting your Arduino to your PWB.

Connect LEDs and crimped connector hardware to the board and preload code (your own or the Prism code provided to you) to the Arduino Mega. Plug the Arduino Mega to the board. The result should look something like Figure 17. **Note:** The three resistors in Region 2 <u>must</u> be installed to test LEDs with Arduino. **ENSURE THAT THE ARDUINO CONNECTIONS LINE UP WITH THE HEADERS (**SEE Figure 18**).**

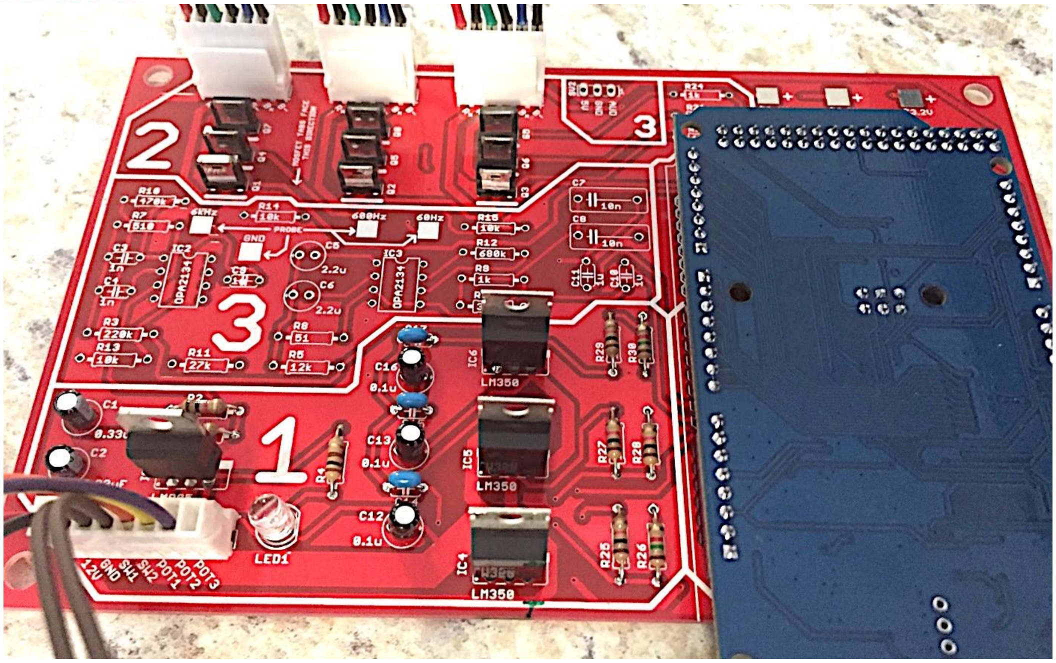

Figure 17: LED connector hardware, and the programmed Arduino Mega connected to the PWB.

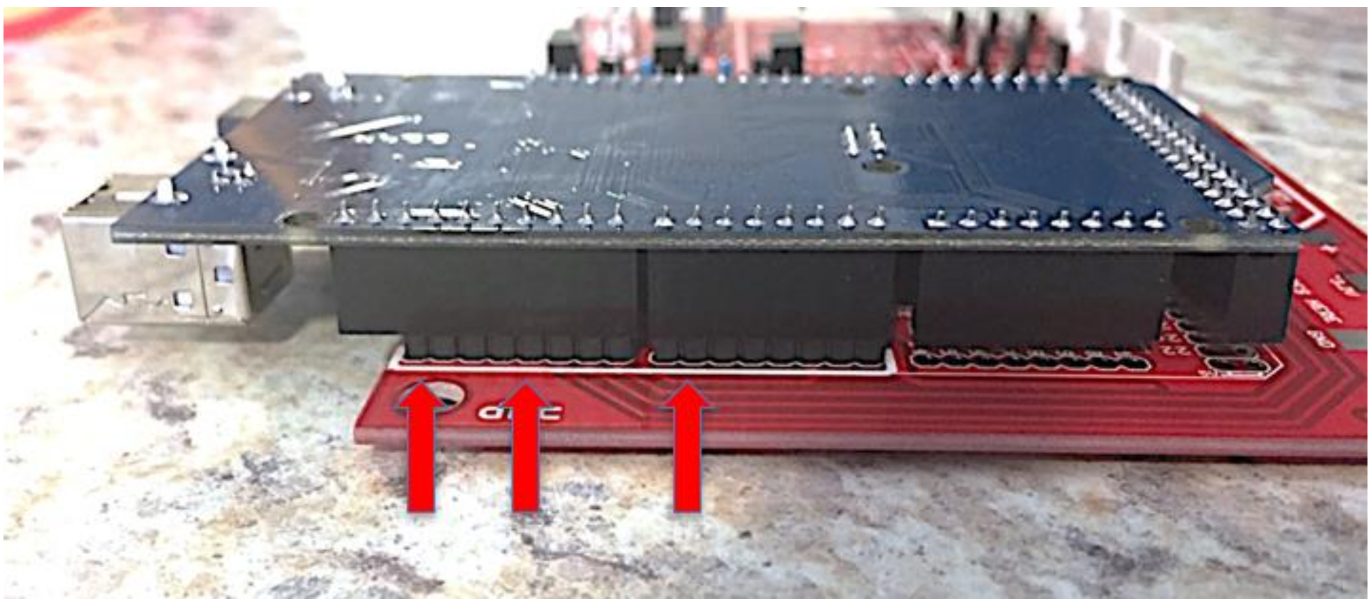

Figure 18: Ensure that the header pins line up correctly with the Arduino Mega and are fully engaged.

STEP 2G: Initial Power-Up

Power up the system by turning on the switch. Once the Arduino is powered on, it automatically runs the program in memory continuously. The Prism code has a test mode. To access it, turn the potentiometer all the way to the right (clockwise) - you should see each LED fade and cycle through the color wheel (shown in Figure 19).

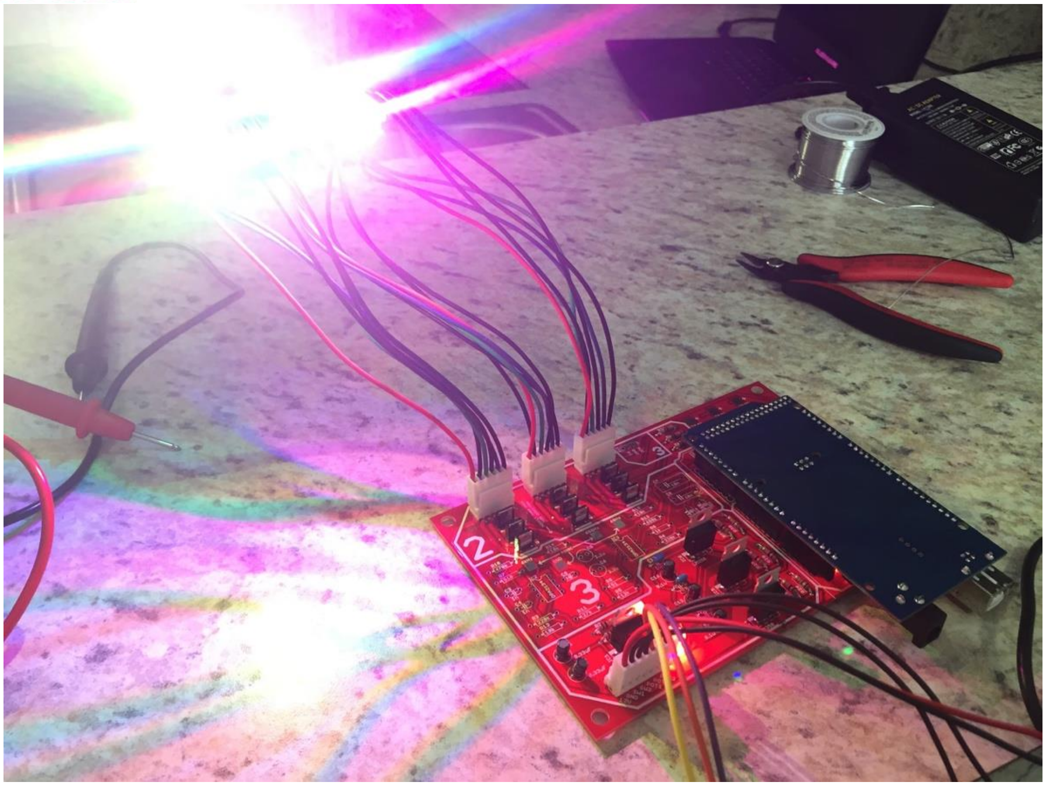

Figure 19: Ensure that all of the LEDs cycle through the color wheel when running the Prism code with potentiometer in fully clockwise position.

STEP 2H: Testing the LED’s

DEMONSTRATE THAT ALL LEDS CYCLE THROUGH THE COLOR WHEEL. FAILURE TO DO SO MAY RESULT IN DIFFICULTY TROUBLESHOOTING LATER.
If any color of any of your LEDs does not light up properly, you must troubleshoot. Start by retesting according to Appendix 2 – Testing LEDs. Once your LEDs are working, continue to Step 3.

STEP 3A: Solder Op Amp sockets

Unplug all crimped header connectors and solder the rest of the components to the PWB (Region 3 components). DO NOT DIRECTLY SOLDER AUDIO OPAMPS TO THE PWB. Instead, solder the 8-pin DIP sockets to the PWB. (See Figure 20 and Figure 21).

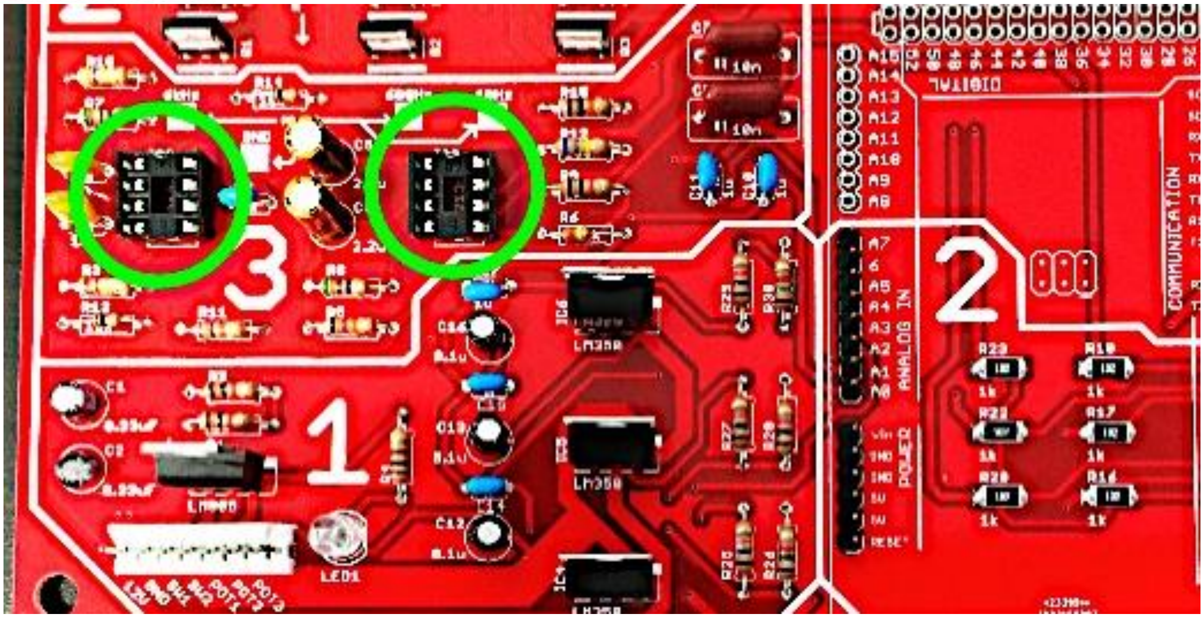

Figure 20: Nearly fully assembled PWB. Green circles show 8-pin DIP sockets mounted to the PWB in Region 3.

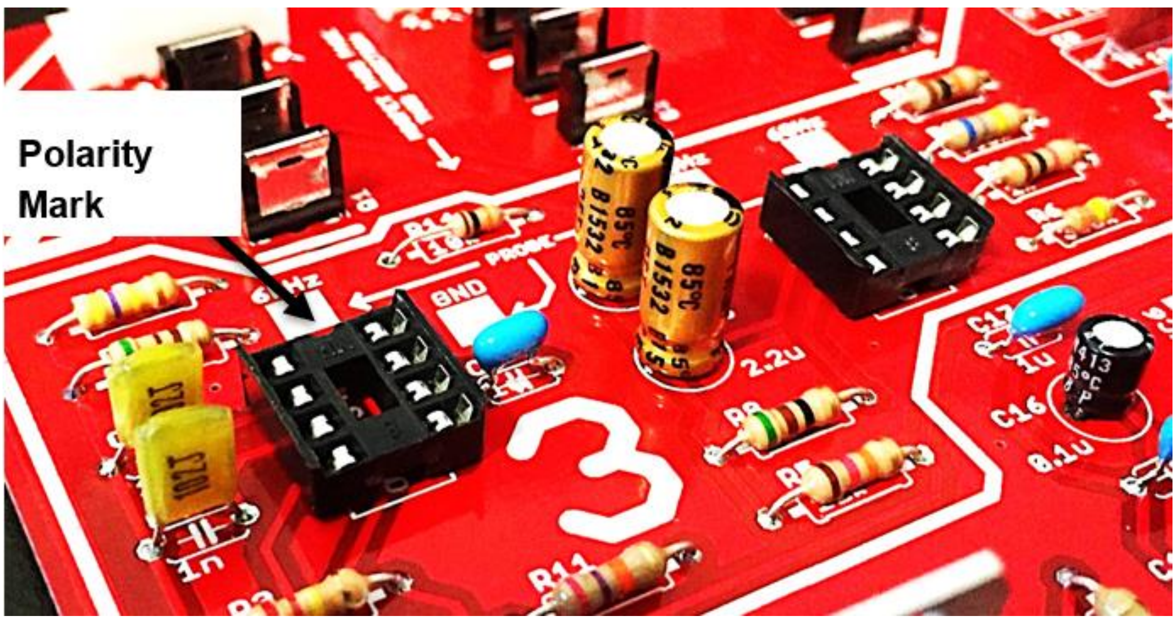

Figure 21: Close-up of 8-pin DIP sockets mounted to the PWB Region 3. Note the half circle polarity mark orientation.

STEP 3B:. Plug audio opamps into 8-pin DIP sockets.

Note: The polarity of the audio opamps is important – the half-circles are oriented toward the top of the PWB. There is also a circular mark on the top of the package identifying Pin 1 – this mark should be in the top left corner. (See Figure 22)

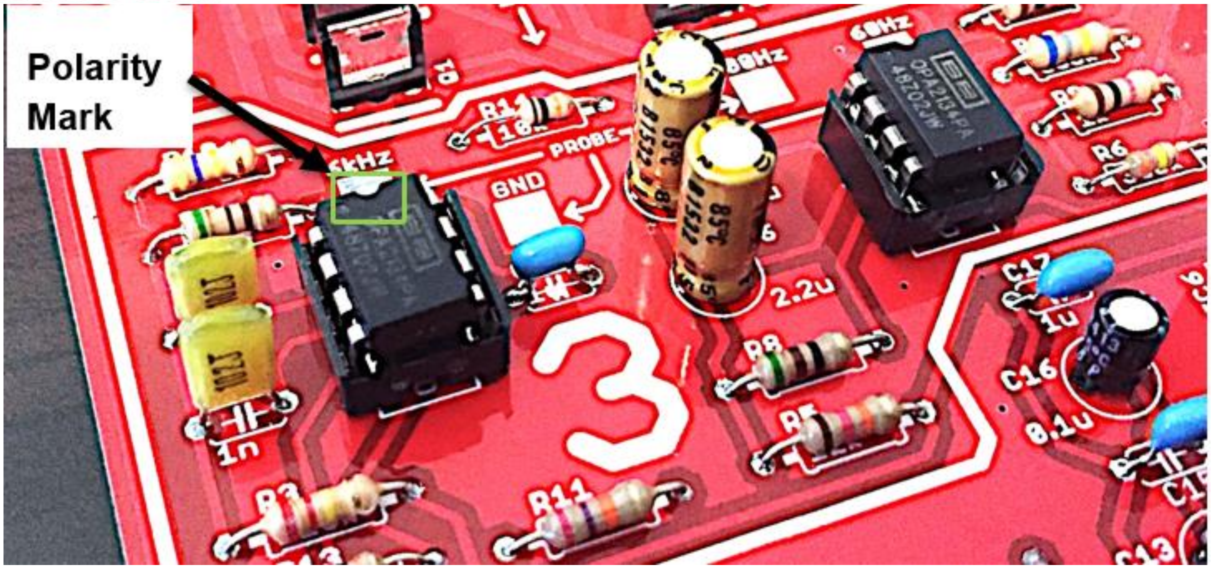

Figure 22: Close-up of audio opamps plugged into 8-pin DIP sockets in the correct orientation. Note the polarity mark on the top corner of opamp (inside rectangular selection).

STEP 3C. Solder the 3-pin 90-degree male header to the microphone board.

The header pins should be mounted on the side that is opposite to the microphone module (see Figure 23). Ensure that no solder bridges form between the pads when soldering. **Note:** Microphones are sensitive to mechanical shock and electrical energy. **Keep your microphone in its original, static-resistant plastic bag until ready to install.**

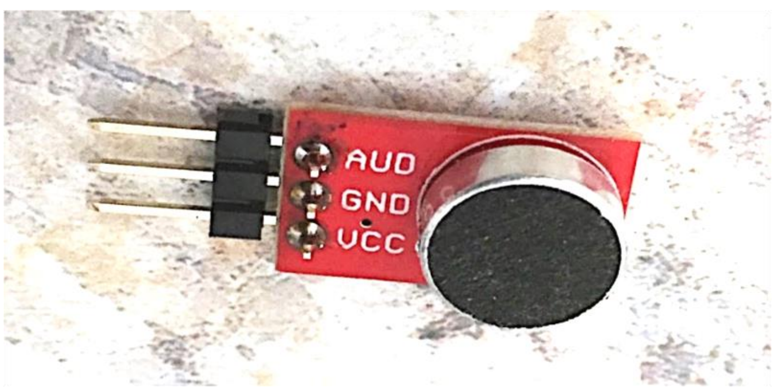

Figure 23: Header pins are mounted using the right-angle male header from the side that is opposite of the microphone module as shown.

STEP 4D: Plug in a devices and cables

Plug in all crimped headers, microphone, LED wiring assemblies and the Arduino Mega. Ensure that the microphone Pinouts match with the PWB. (i.e., AUD Pin plugs into the AUD port). Power up the system. With the microphone board installed, check the voltage is 2.5V on the test pads next to the mic.

STEP 4E.: Check sensitivity and adjust as necessary

Try adjusting the potentiometer (sound sensitivity) while simultaneously tapping the microphone to see if the lights react. Rotating potentiometer clockwise puts the system in LED test color mode; counterclockwise puts system into increasingly sensitive microphone mode. Contact your instructor or TA for a demonstration if you wish. When the sensitivity is set correctly, use a tone generator connected to computer speakers to independently check the high, mid and low frequency response (60 Hz, 600 Hz, and 6,000 Hz)

Congratulations! You have finished assembling your PWB for the EDM prism LED project!

Post-Soldering Cleanup

We use rosin-core solder in the lab, which is typical for hand soldering. Rosin is an organic material that contains a slightly basic reducing agent (flux) that deoxidizes the metal surface to prepare for soldering. During soldering, flux spreads over the solder pad, but also beyond onto other areas – particularly when excessive solder is applied. Flux residue is sticky until dry and may attract debris, which may be a concern for shorting and/or may contaminate subsequent processing. Excessive flux residue can appear as 'glassy pools' that harden when dried around soldered areas on the PWB. Flux residue is sometimes removed, but not always. It can be removed by hand, so our goal is to attempt to identify and remove some of the flux residue from our PWBs.

To remove hardened flux residue, an Xacto knife or scratch awl can be used to scrape and break it up, then brush away with a paper towel, cotton swab or acid brush. There are acid brushes in the tool cabinet near the pliers that work well for this. Alternatively, a solvent such as isopropyl alcohol (IPA) can be applied using an acid brush – which will dissolve flux so that it may be soaked up with paper towel or cotton swab to remove. If using IPA, work in small areas of a few square centimeters at a time – applying and wiping up the dissolved residue frequently. There may be a white, powdery residue remaining from the IPA, this is perfectly acceptable, it is not sticky so won't collect debris. For maximum points, you MUST attempt to remove some flux residue from your PWB by some method. The PWB does not have to be 100% free of flux residue – the goal is to demonstrate you can remove flux reasonably well. It is recommended that you wait until you are done soldering to the PWB to remove flux residue.
Note: Isopropyl alcohol (IPA) is poisonous if ingested and flammable. Do not expose to heat or flames.

Chassis Installation

Once the Prism system is tested and functioning correctly, the final steps are the assembly of the Prism system into the awesome chassis you built. Please see Appendix 6 for final chassis assembly instructions.

Troubleshooting

Refer to this section if you find that your PWB or other part of your system does not work as expected. Troubleshooting is organized into sections corresponding to assembly steps. Possible Causes are listed beneath each symptom (ranked in decreasing order of likelihood):

Region 1 Issues

The LED indicator does not turn on.

- *Check power jack wiring* – must be in accordance with Figure 7.
- *Poor crimping* - Use a multimeter on continuity mode to check that electrical connections are being made between the crimped header and each of the panel mount components.
- *Poor soldering* - Visually inspect the underside of the PWB to check for bad solder joints. In addition, use the digital multimeter on continuity mode to ensure that connections are being made between electronic components that have traces between them.
- *LED is mounted in reverse* - Remember that this component is polarized. If you carefully look at the base of the LED, you will notice that it is not completely round, but instead, there is a flat side - which corresponds to the cathode (-).
- *Incorrect voltage regulator is installed* - Make sure that the LM7805 voltage regulator is installed in IC1.
- *The DC power supply is defective (rare case)* – Is the LED continuously illuminated on the power supply? Try an alternate DC power supply.
- *One or more components get hot* - this means that a short has occurred causing excessive current flow and overheating.
- *Short across a component* - If a short exists on the board, no current will pass through the LED. The culprit will most likely be a faulty capacitor. Other possibilities include solder bridges - this usually happens across voltage regulator pins.
- *Faulty voltage regulator* - Sometimes a voltage regulator may be faulty, and may behave unpredictably. If the LED indicator works, IC1 should be fine. Remove IC4, IC5, and IC6, one at a time, until the problem is fixed - then replace the faulty regulator.

All test pads output voltage, but the measured voltages are not in the correct range.

- Incorrect resistor placement - Check to make sure that the correct resistors have been mounted in R25, R26, R27, R28, R29, and R30.

One or more test pads output no voltage, or the incorrect voltage.

- *Bad solder joint/connection* - Check to make sure that the voltage regulators are correctly soldered to the board.
- *Faulty voltage regulator (rare case)* - Sometimes a voltage regulator may be faulty, and may behave unpredictably. If the 2.4V pad is outputs no voltage, there is a problem with IC5. If the left 3.2V pad outputs no voltage, there is a problem with IC4; otherwise, if the right 3.2V pad outputs no voltage, there is a problem with IC5.
- *Faulty PWB (very rare case)* - Use a digital multimeter to check that there is electrical continuity between each of the voltage regulators (IC4, IC5, IC6) and the test pads. If there is no continuity, you may need to manually route a wire to bypass a faulty PWB trace.

Region 2 Issues

No colored LED lights come on.

- *Transistors are not mounted correctly* - Ensure that the tabs of the transistors are facing the correct direction.
- *Some resistors are missing or are not installed correctly* - Check that R16, R17, R18, R19, R20, R21, R22, R23 and R24 are mounted correctly.
- *The Arduino Mega is not mounted to the PWB correctly* - Ensure that the header pins are aligned with the Arduino headers.
- *The Arduino Mega does not have the correct program uploaded to it* - Upload the supplied code given to you by your instructor.

All LEDs blink erratically.

- *This should be normal (for now)* - Try turning the potentiometer all the way to the right (clockwise). This should set the program to debug mode, which should cycle all LEDs. If this does not solve the problem, see below.

Only some of the LEDs blink erratically.

- *An LED may have a short across it* - Test the LED to make sure that it has been soldered and mounted to the heatsink correctly. Try swapping the plugs of a “good” and “bad” LED wire harnesses to isolate if the problem exists in the LED/wire harness, or on the PCB board.
- *The Arduino Mega is not mounted to the PWB correctly* - Ensure that the header pins are aligned with the Arduino headers.
- *Defective LED* - Sometimes the LED may be defective and will need to be replaced.
- *One or more of the MOSFET transistors may be defective (rare case)* - If you already ensured that the LEDs are working correctly, the MOSFET transistors may be defective. Typically, you will see one or two colors out of the three colors behave strangely.

All LEDs blink erratically.

- This could be normal - Try playing with the potentiometer and turn slowly until the lights stop blinking. Next, tap the microphone and see if the lights respond.

Some LEDs blink erratically.

- Some components may not be soldered in the correct place, or may not be soldered correctly - Check all components and soldered connections.

Glossary

footprint: The physical arrangement and/or area containing, including the markings, of a component on a printed circuit board.

lug: An external appendage of a component that you solder to. It usually has a through-hole of some sort that allows you to feed a wire through. Also used synonymously with ***terminal***.

multimeter: An instrument used to measure voltages, current, and resistance (and sometimes capacitance). It is often abbreviated DMM (digital multimeter) or DVM (digital voltmeter).

pad: The interface on/in which a component is mounted via soldering. Pads are typically lightly pre-tinned with a thin layer of solder.

polarization: Having a particular anode (+) and cathode (-) association with a component's leads or representing the direction of current flow. Some components are polarized. For capacitors that are polarized, the positive lead is slightly longer and in some cases a negative sign (-) is marked on the body nearest the negative lead.

potentiometer: A three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat.

PWB: Printed circuit board… a.k.a., printed wiring board (PWB).

Terminal: See ***lug*** *(h*ey, at least lug doesn't have a circular or recursive definition like some dictionaries do).

Appendix

Appendix 1 – Crimping

Crimping is the process of attaching a metal crimp connector to terminate a bare wire using a crimping tool. Crimped interconnections allow the use of multi-pin connectors as an efficient way to interconnect with off-board components. They are stronger than soldered connections.

For crimping panel mount components (switch, potentiometer, power jack) cut seven 22 or 24 gage wires to approximately 6-inch lengths. The colors of the wires do not matter, but ensure that you can follow figures 4 through 7 to ensure correct order of the wires in the 8-position header.

Crimping requires 1/8 inch of bare wire be exposed by removing the insulation jacket with wire strippers. The relative positions of the crimp and stripped wire are shown in Figure 24

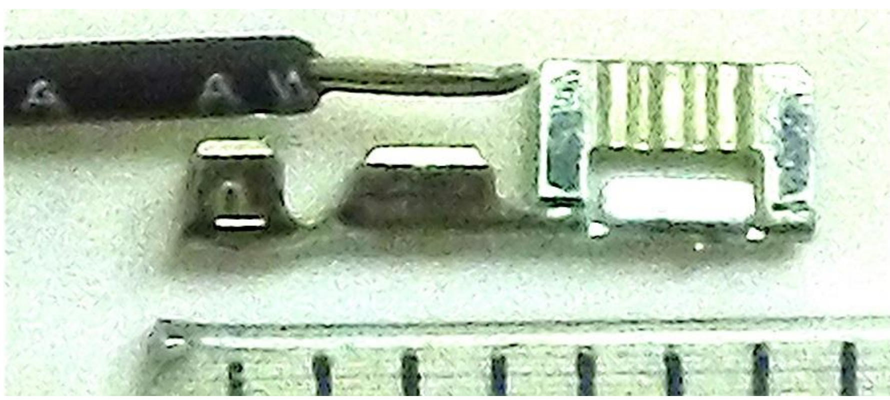

Figure 24: Wire with 1/8 inch of insulation stripped off before crimping. (Each division on scale = 1/16th inch).

Two variations on crimping technique will be described:

1. Place the stripped wire in the crimp and pinch the rear, narrow tabs around the insulation slightly with pliers to hold in position temporarily. Then, place the crimp with the wire held to it in the crimping tool and perform final crimping operation.
2. Alternatively, load the crimp in the spring-loaded holder of the crimper tool first, and then insert the wire into the crimp with the amount of overlap shown in **Error! Reference source not found.**. Make sure that the large part of the crimp is enclosed in the spring-loaded capture mechanism. Squeeze the crimper handle until completely closed, and then reopen. Release the crimp from the holder. A properly crimped wire is shown in Figure 25.

Figure 25: Crimped wire showing plastic jacket crimped by left tab and bare wire strands crimped by right tab.

After crimping wires, visually inspect to ensure that the crimp tabs are positively formed over the wire strands and plastic jacket as shown in Figure 26. If either tab is insufficiently formed around wire to hold mechanically and electrically, you may be able to re-crimp again with the crimper tool. You may also repair the crimp (at least make it work) by further bending the tabs by pinching together with pliers.

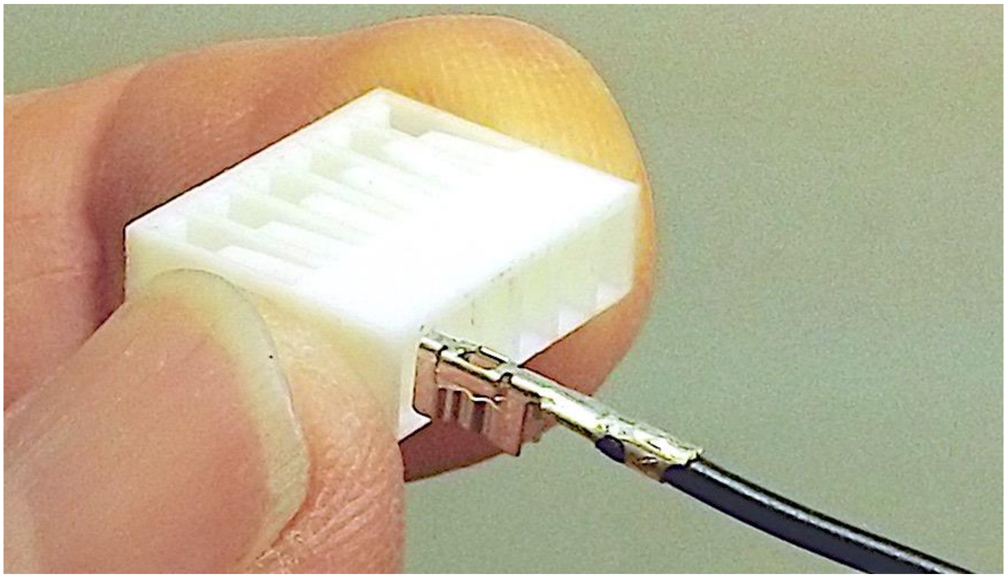

Figure 26: Orientation of crimped wire and multi-position header for correct insertion of crimp.

After inspecting to verify crimps are properly formed, install the crimped wire into the slot of the multi-position header in the orientation shown in Figure 27. Before installing crimps, verify that the correct wires are selected for each slot in accordance with the board markings. Upon insertion, a tiny click should be heard or felt when the crimp is entirely inserted. This is the sound of the locking tab snapping against the plastic header body. Install the remaining wires similarly.

Appendix 2 – Assembling LEDs

Each RGB LED requires six connections, two for each color (one positive and one ground). Cut 18 pieces of wire, approximately 14 inches long for wiring all LEDs. The color of the wire does not matter, but you may wish to use Red, Green and Blue for the nine positive wires and Black for the nine negatives (Ground).

One end of each wire will be crimped to a six-position header and the other will be soldered directly to the LED pads. You may crimp or solder wires first, order does not matter. Please see Appendix 1 for crimping instructions. Ask a TA or instructor for assistance if you wish.

For soldering to LEDs, once you have your 14-inch lengths, strip $^1/_8$ inch insulation from one end of each wire to be soldered. Before soldering, tin the wire ends with a light coating of solder as shown in Fig 28. Note that the iron is positioned below the wire and solder added from the top. Helping hands may be useful for holding the wire while tinning as shown.

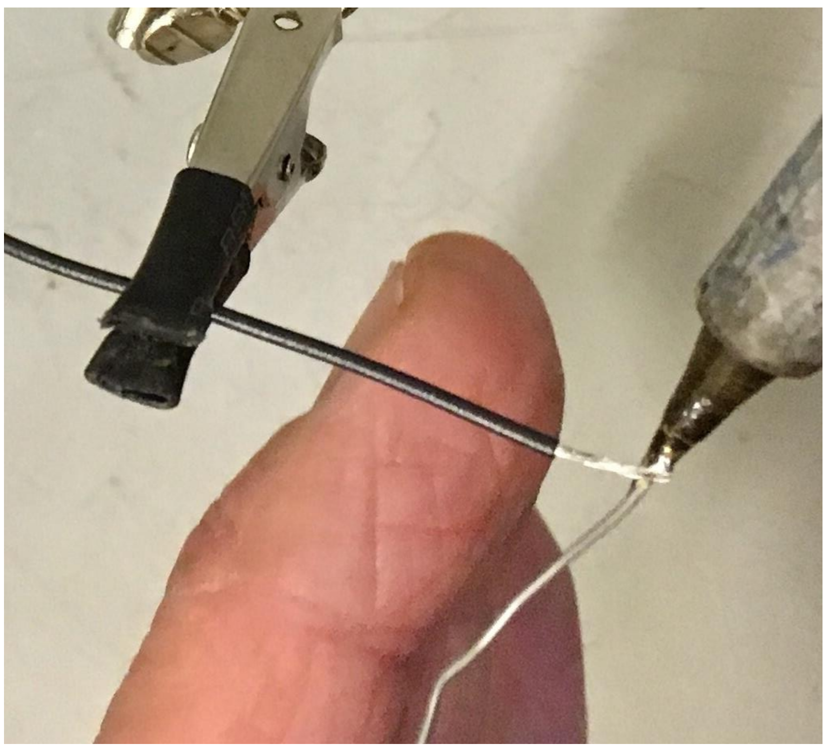

Figure 27: Tinning stripped LED wire before soldering using helping hand.

Appendix 3: Soldering LEDs

To prepare to solder, you may tape the LEDs down to secure as show Figure 28. Do not mount the LED's to the heat sink as this will overheat the wires when attaching them to the LED..

Note the R, R-, B, and B- markings next to the LED pads corresponding to the positive Red, negative Red, positive Blue, etc. There are no markings for the Green pads. Place the appropriate tinned wire against the corresponding pad with the wire perpendicular to the edge of the LED and tape down to secure wire in position as shown in Figure 28.

Cut 18 pieces of heat shrink tubing, ½ " in length. Slide the heat shrink tubing over each of the 18 wires before soldering the wire to the LED. After wire soldering is complete, slide the tubing over the solder joint as close to the LED as possible, then use a heat gun to shrink the tubing tight around the wire. This extra insulation will avoid shorting of the wire with the heat sink. (See Figure 31)

There should be enough solder on the tinned wire to melt with the solder on the pads sufficiently to join them. You may wish to bend the wire downwardly slightly to ensure it remains in firm contact with the pad during soldering. It is very important not to bridge solder between the Green pads and the adjacent LED pins (see Figure 29). This will cause shorting and erratic LED behavior. Do not apply excessive heat while soldering, to avoid the wire insulation from pulling back and exposing too much bare wire.

After soldering, tug on the wires gently to ensure the joint is strong. The soldered LED should look like Figure 29 when completed. Shrink the tubing around the exposed insulation next to the solder joint.

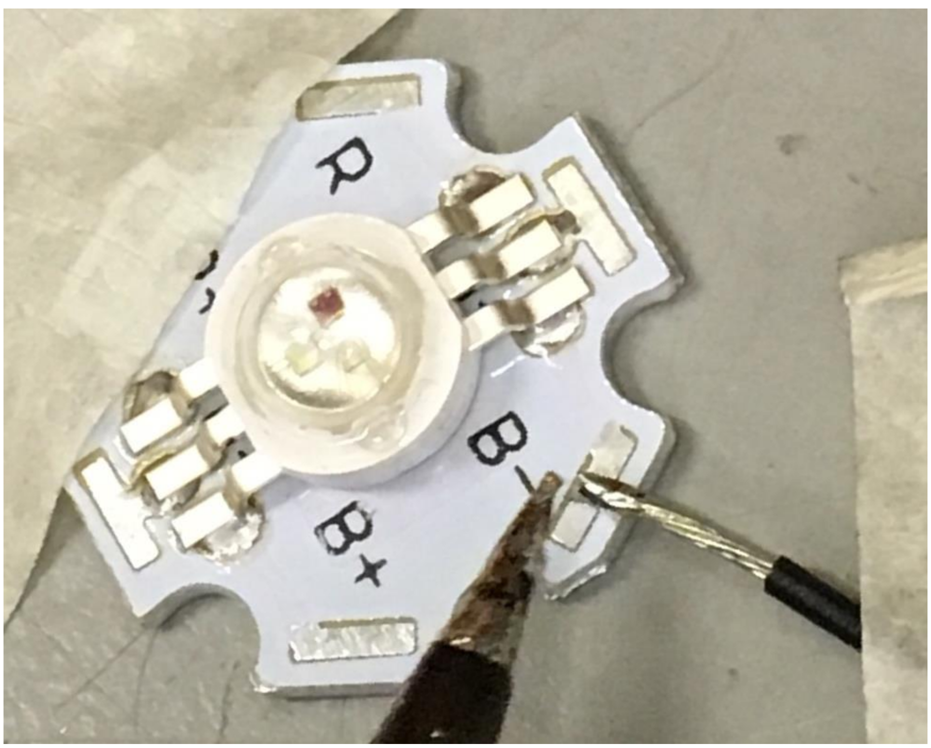

Figure 28: Soldering LED wires perpendicular to the edge of the LED

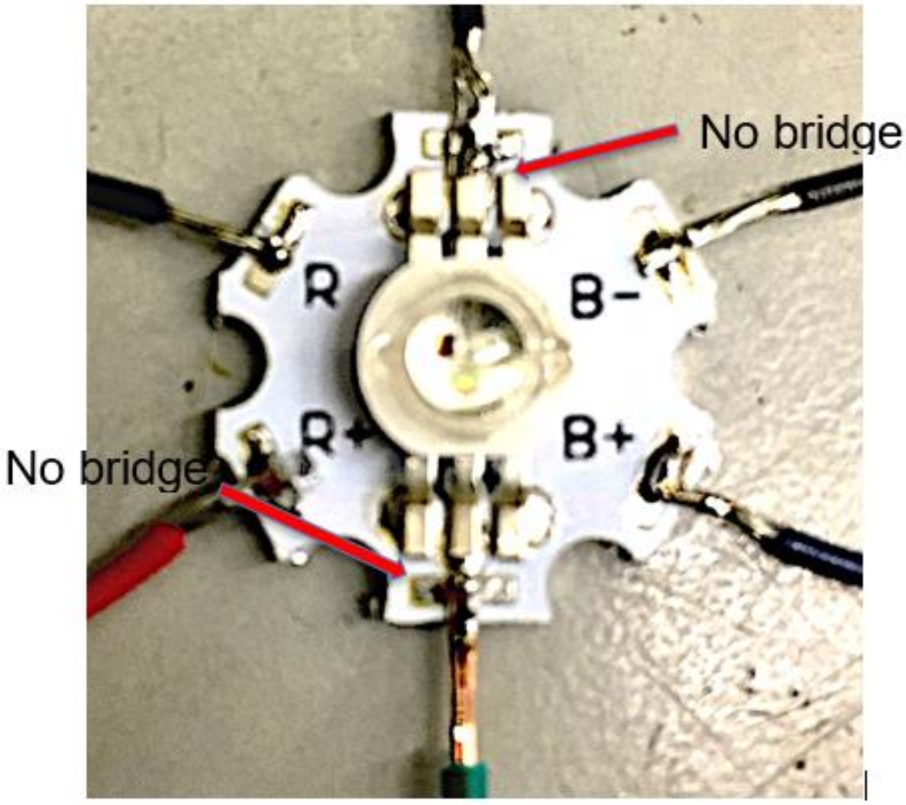

Figure 29: Soldered LED. Note: there is no solder bridging between Green pads and adjacent LED pins (see arrows).

Appendix 4: Mounting LEDs to Heat Sinks

LED heat sinks have a circular pattern of round openings for mounting screws. Use the smaller, innermost holes for mounting screws (see Figure 31). Use two #4 counter sink sheet metal screws to attach LEDs to heat sinks. Any two opposing screw holes may be used to mount, but **make sure that screws do not touch any wires or solder** (see Figure 30). This may cause shorting and malfunctioning of LEDs and voltage regulators providing power.

Once LED/Heat sink assembly is completed the next step is testing the crimps and solder interconnections.

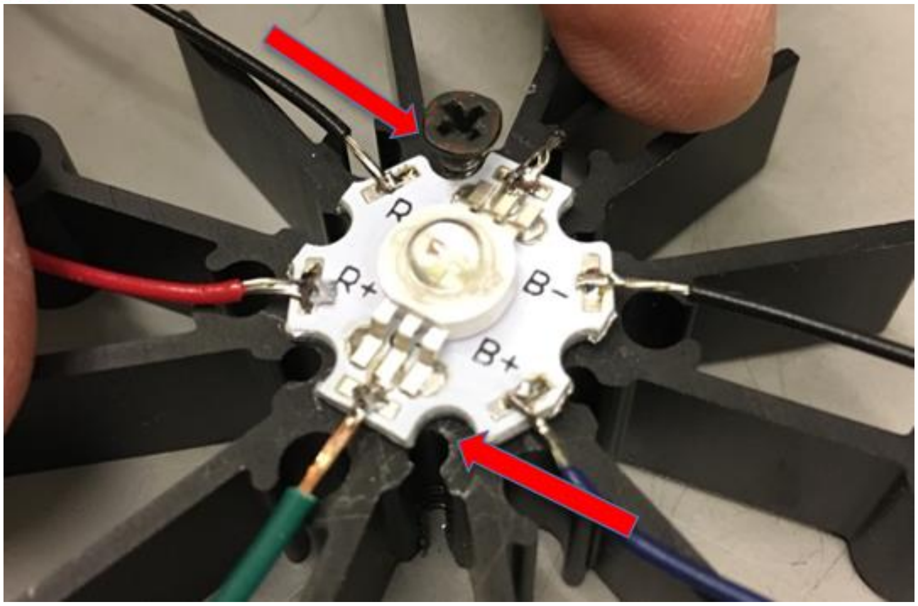

Figure 30: Install #4 counter sink screws using smaller, innermost holes (arrows).

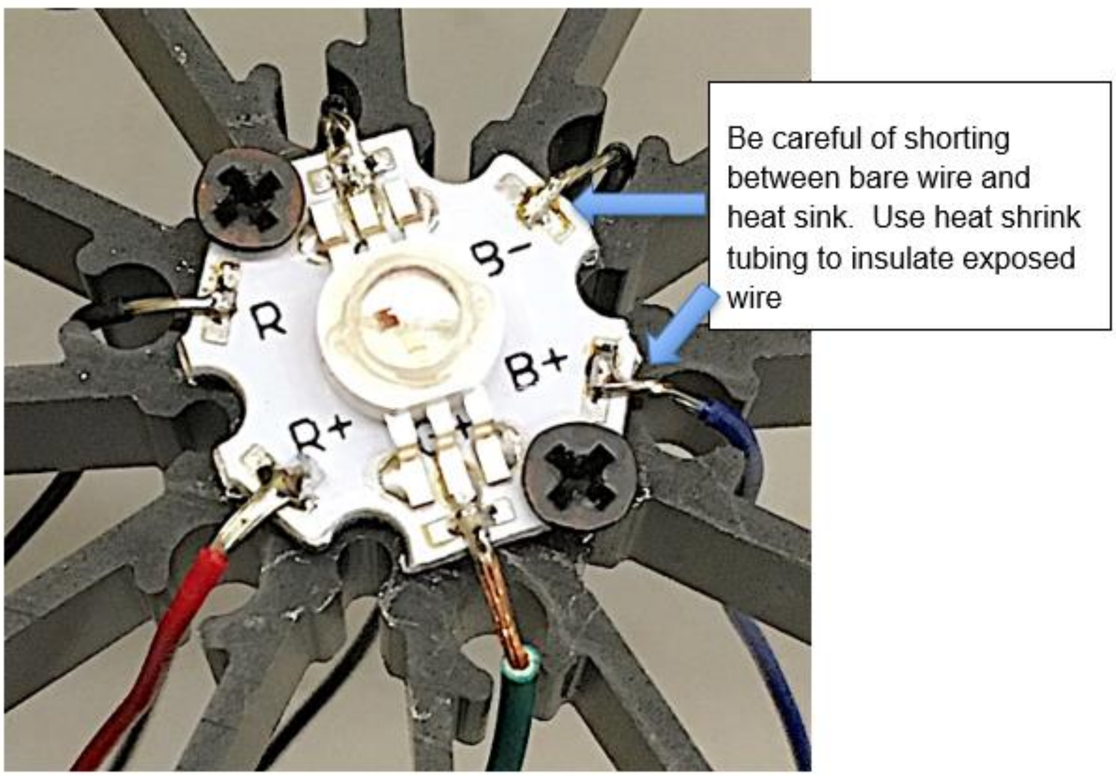

Figure 31: Completed LED/Heatsink assembly. Note: Screws are not touching solder or wires and wires are not touching the heat skink. (heat shrink protection not shown)

Appendix 5: Testing LEDs

A quick test should be done to test the integrity of the LEDs, wiring and crimps after assembly. First, install the six crimped wires into the 6-position plastic header in the correct order as shown in Figure 32. Test the connections and LEDs using the multimeter in continuity mode by touching the multimeter leads through the connector slots to the exposed crimps. **Note:** you must have the multimeter lead polarities correct. Each color of the RGB LED should light up. If an LED does not light up check the crimps. Ask a TA or instructor for assistance if you wish.

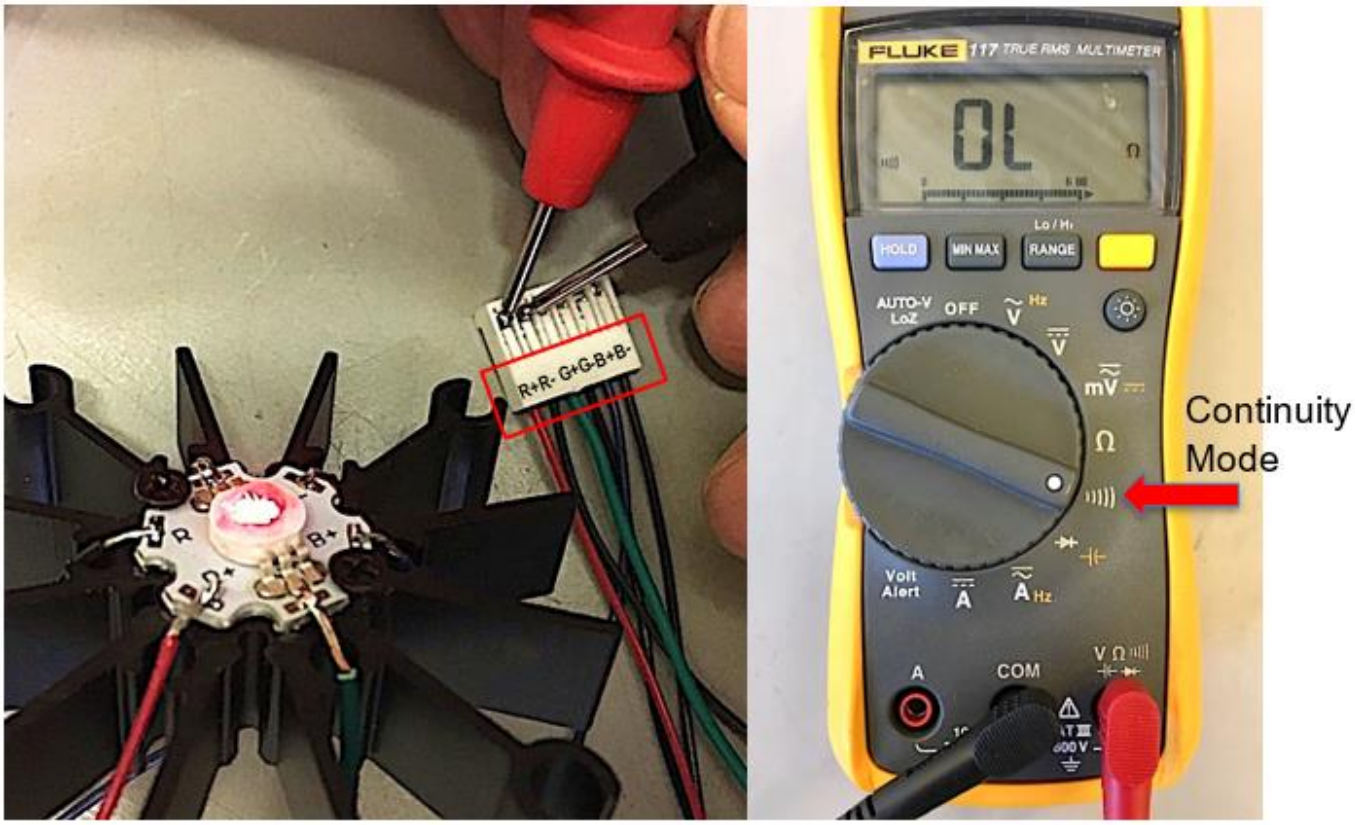

Figure 32: Testing RGB LEDs using multimeter in Continuity Mode. Note positions of LED wires in header and polarities of test leads.

Appendix 6: Final Chassis Assembly Instructions

Assembling LEDs in Chassis

Attachment of the Prism LEDs to the top of chassis will require the six #6 x 1.5-inch machine screws, long plastic spacers, #6 hex nuts and star lock washers included in your kits. Three plastic light diffusers (not included in kit – supplied in the lab) are installed atop the LEDs as shown with all hardware installed. (Figure 34)

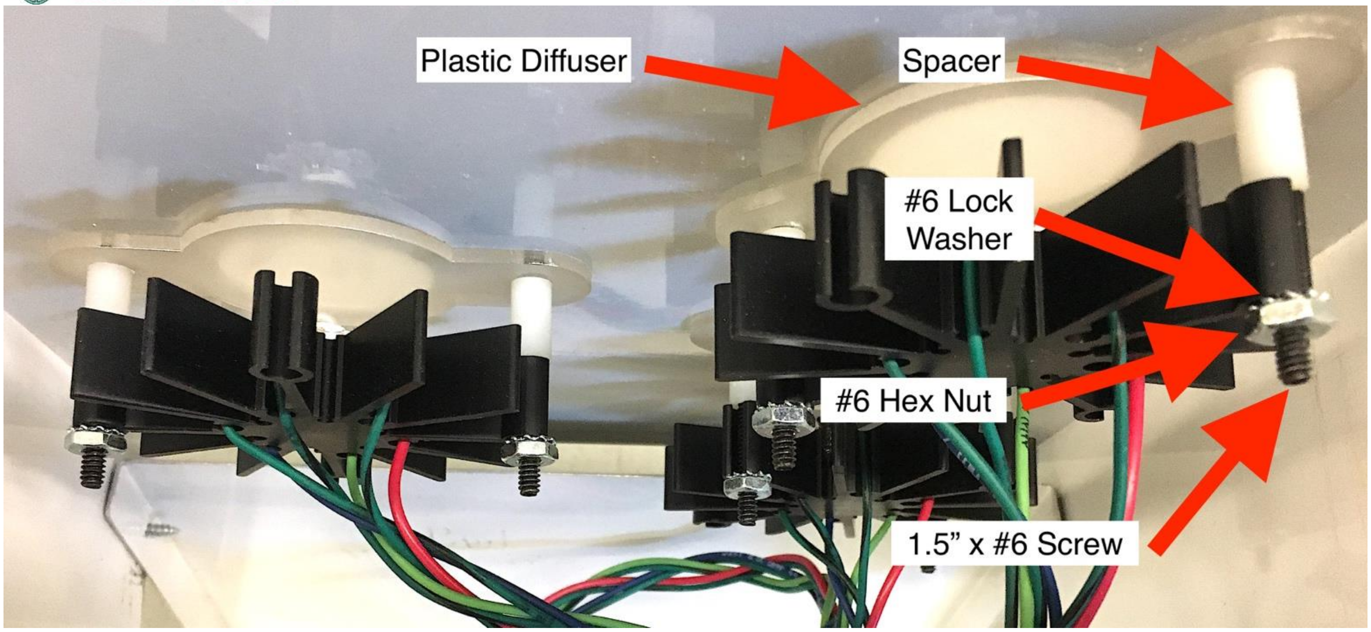

Figure 33: Assembly of LEDs into top chassis using plastic diffusers (supplied in lab), screws, spacers, nuts and lock washers.

Assembling Panel-Mounted Components to Chassis

The On/Off switch, potentiometer and power jack mounting are as shown in Figure 34. Note that the power switch must be installed from outside the chassis – the wiring with either require de-soldering and re-soldering after installation or temporary removal of switch crimps from 8-position header. **Note:** The switch may not fit into the punched hole easily; to increase the clearance, carefully file the edges of the hole. Any file may be used, but <u>be careful not to remove too much material</u>.

The potentiometer and power jacks are installed from inside the chassis by removing their attached hex nut and washer, installing in chassis mounting holes and re-attaching washer and nut and tightening with pliers. **Note:** The potentiometer has a locking pin that prevents rotation which must be aligned with the small hole located just below the larger, main hole. (See 5) Potentiometer and power jack nuts **must be tightened with a tool such that they cannot be loosened by hand (worth points!).**

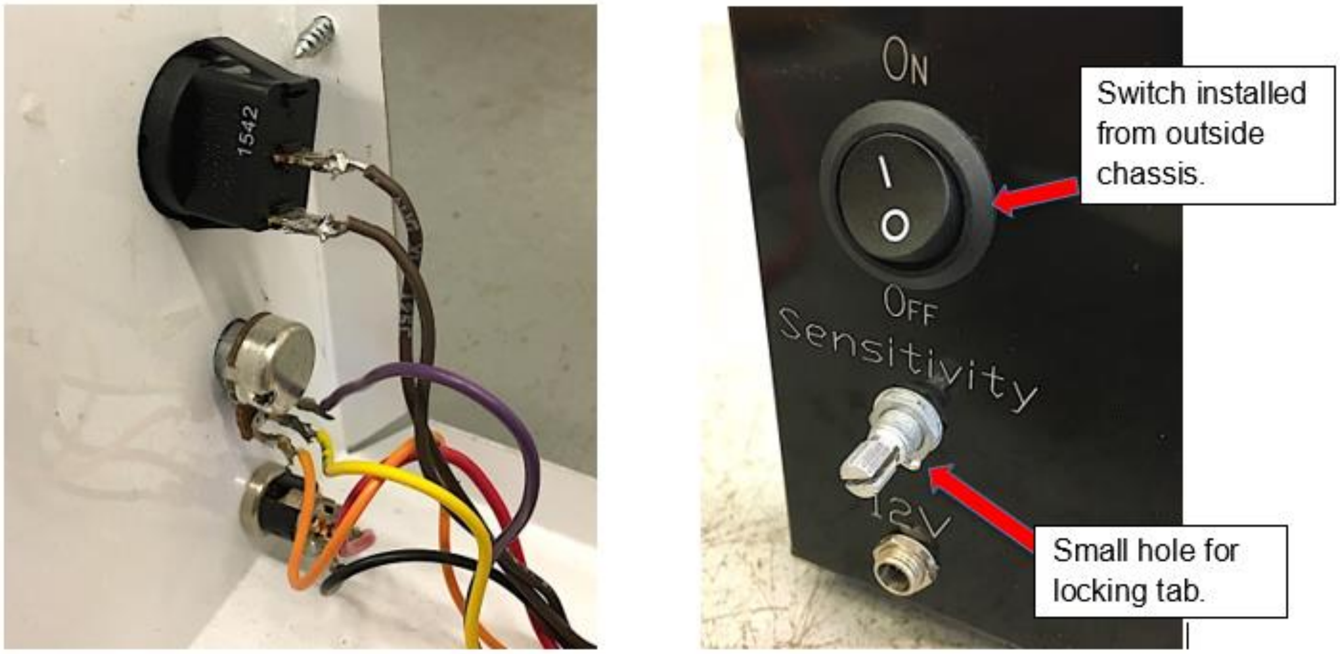

Figure 34: Assembly of panel-mounted components. Note potentiometer locking tab/hole alignment.

Attaching PWB to Chassis

The PWB is mounted to the chassis using four #6 x .5-inch screws installed through the four punched holes in the bottom of the chassis as shown in Figure 35. **Note: Lock washers <u>must</u> be installed under each hex nut and nuts <u>must</u> be tightened with tools so that fingers cannot loosen the nuts (worth points!).**

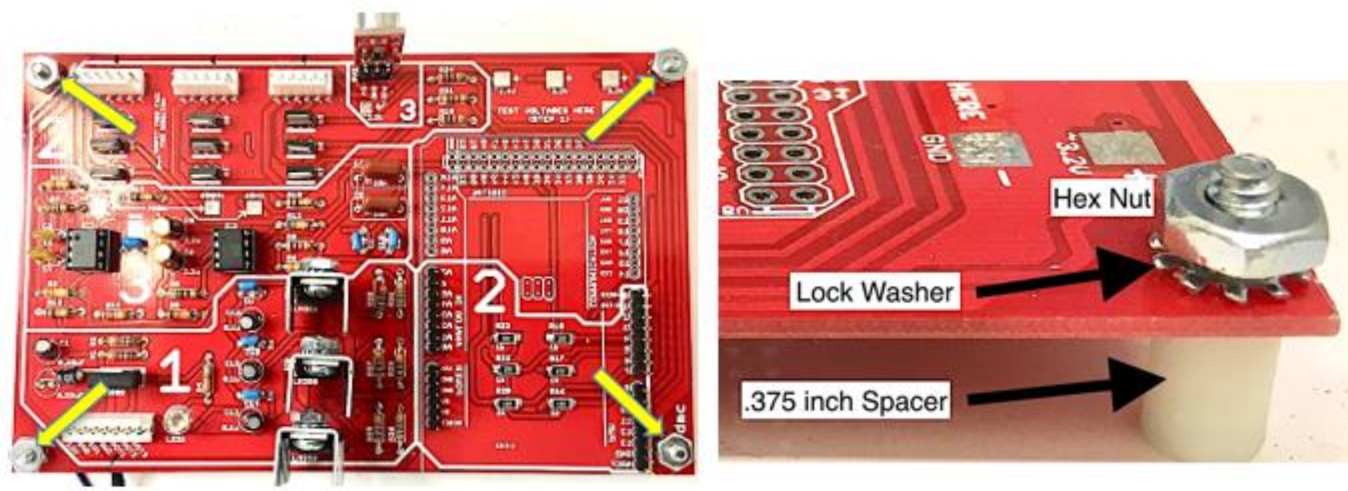

Figure 35: Locations of corner mounting screws and assembly of hardware for PWB attachment.

After installation of PWB, install connector headers for LEDs and panel mount components, plug in power and test your Prism system for proper functionality. Tap on the microphone to verify the LEDs light up in response to sound. If no LEDs light up while simultaneously tapping while adjusting the sensitivity, verify that your microphone is working by measuring the voltage at the mic test pad (should be ~ 2.5 V). If a voltage of ~.6 V is present at the mic test pad, you have a blown microphone. (See your instructor).

Testing with music at moderate volume should activate LEDs. The volume of music from a phone may not be loud enough to activate LEDs - amplification with powered speakers may be required. Adjust sensitivity knob throughout full range to realize the range of music volumes sufficient to activate system to your taste. Note: The Prism code provided has an LED test mode activated when the sensitivity knob is fully clockwise.

Final Assembly of Prism System

When Prism system is fully functional, install wire dressing (tape or zip ties) to the three LED wire assemblies <u>and</u> panel mount wiring to secure. This will help keep wiring neatly bundled.

Finally, install the six #6 x .375-inch sheet metal screws to attach the top to bottom chassis.

Congratulations! Enjoy your sound-activated Prism LED system.

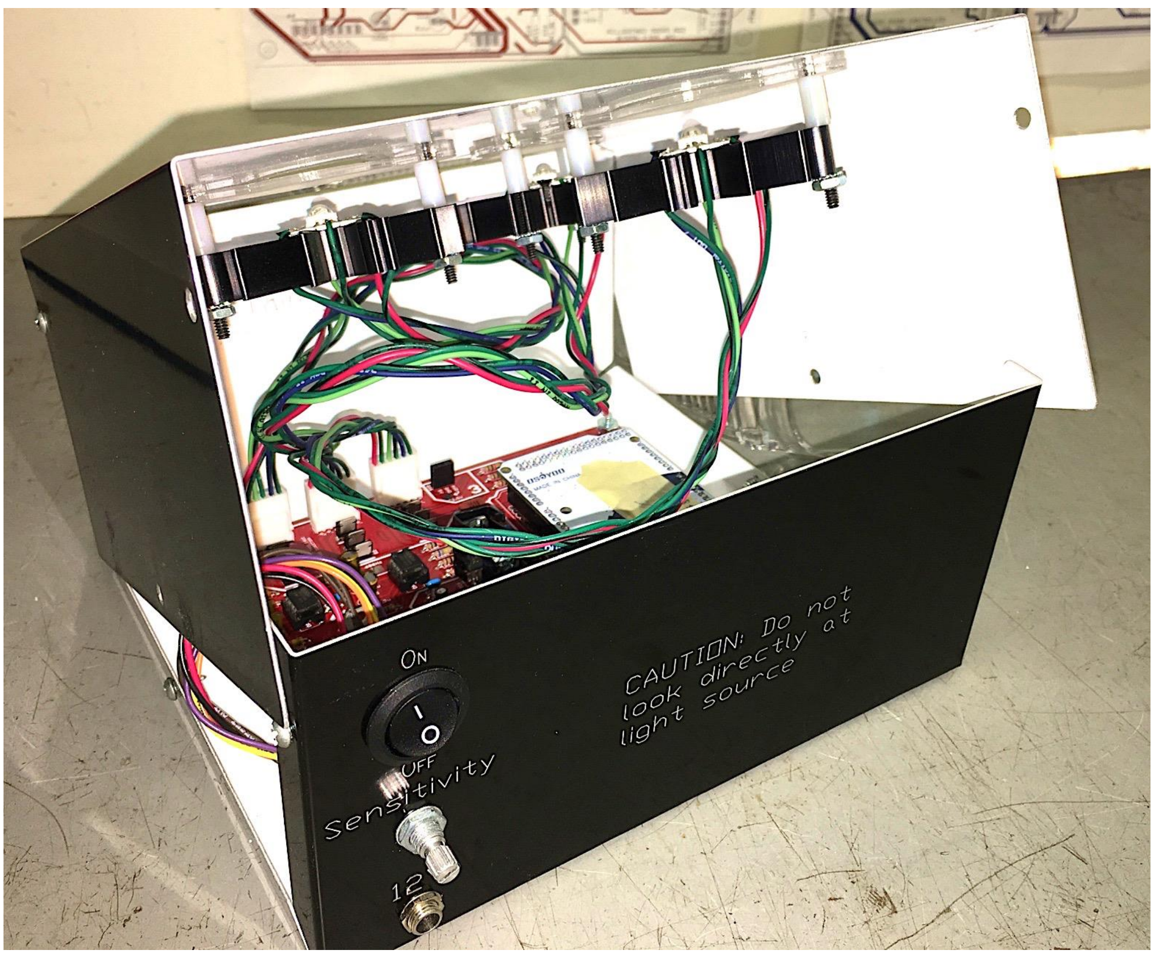

Figure 36: Completed Prism system. Note: here wires were braided to secure instead of using tape.

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