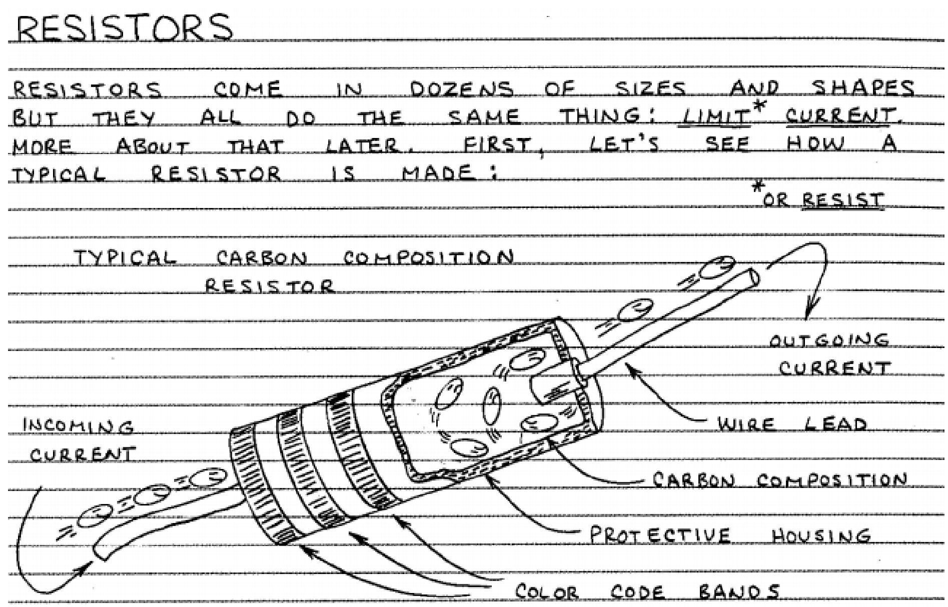
1 Background

Before we begin soldering, let's briefly cover some basic electronic components.

1.1 Resistors

The simplest electronic component is the resistor; they get their name because they resist the flow of current. If you imagine electricity as water, the resistor is a pipe of some diameter. The smaller the diameter of the pipe, the less current that will flow. A resistor with a high resistance will act like a narrow pipe. Each resistor is rated for a value measured in Ohms (Ω) and they typically range from 1-1$M\Omega$.

Figure 1: Credit: Forrest M. Mims

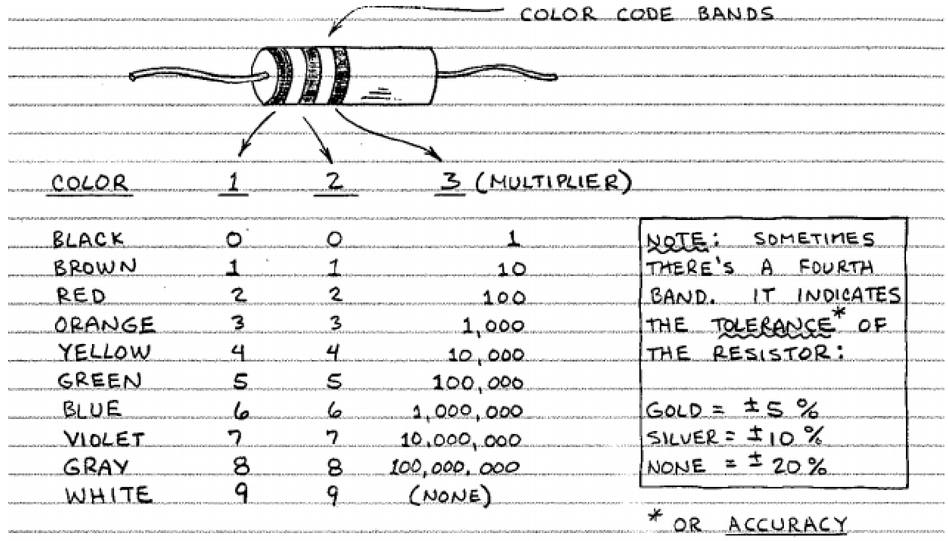


A resistor can be seen here, notice the color bands on the body of the resistor. These are used to indicate the resistance value of the part.

Figure 2: A Resistor

To find out the value based on the color code, the table below is helpful. The colors are mapped to numeric values based on a modified rainbow (Black-Brown-ROYGBIV-White). The value is analogous to scientific notation. For a 4 band resistor the first two bands represent the "a" in $a \times 10^b$, the third band represents the "b". Finally, the fourth band represents the tolerance of the resistor (how accurate the resistance is to its rated value). For some applications, there can be a very narrow tolerance for the circuit to work correctly. There are also online resistor code calculators that speed things up greatly.

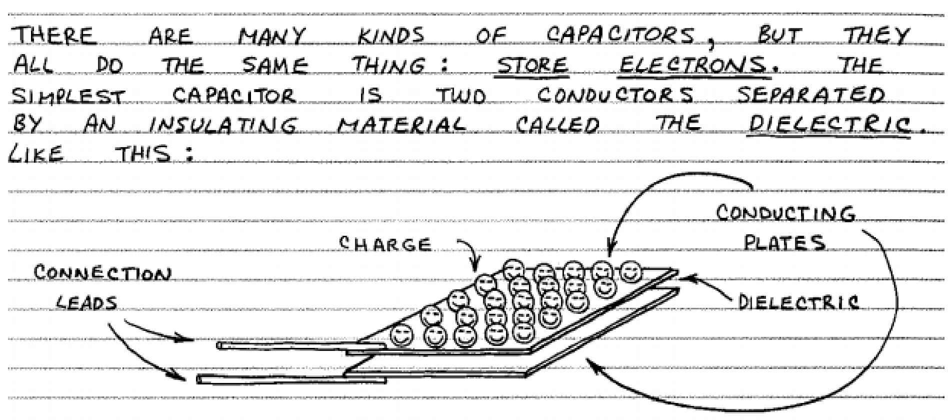
Figure 3: Credit: Forrest M. Mims



1.2 Capacitors

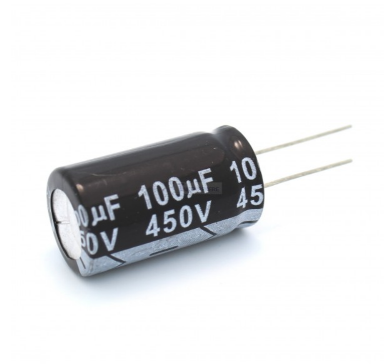
The next component is the capacitor, it is essentially a storage tank for electricity. In the water model it would act like a water tank, where it takes time for the tank to fill and drain. The time to fill the tank is dependent on the rate of the flow (current) as well as the size of the tank. Capacitors have a “capacitance” value that represents the size of the “tank” and it is measured in Farads (F). Typically, this value is small. For hobbyist electronics, values are around $10^{-6}F$ which is typically denoted by the Greek letter mu, as in μF.

Figure 4: Credit: Forrest M. Mims



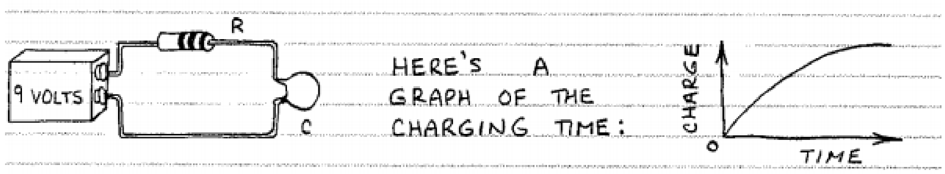
Below is an image of an Electrolytic Capacitor. Other types of capacitors include ceramic and film. The main difference in these capacitors is the range that they operate. Electrolytic capacitors typically have a higher capacitance than ceramic, but Electrolytic caps have the consequence of being *polarized.* A polarized component is one that has a positive and negative lead. If the capacitor is connected backwards and there is significant voltage it can cause the component to fail, and possible burst. The capacitor will have the polarity indicated on the side. Usually negative lead is labeled, additionally, the positive lead will the longer of the two.

Figure 5: An Electrolytic Capacitor



By combining a resistor and a capacitor an RC circuit is made. The resistor limits the current into the capacitor which decreases the rate is charges by, and therefore creates a delay in voltage. The image below shows the graph of this occurrence. By selecting specific resistor and capacitor values the delay time can be set.

Figure 6: Credit: Forrest M. Mims



The circuit we will be building relies on an RC circuit to blink LEDs. Essentially it charges the capacitor through one resistor, and once the voltage reaches an upper threshold, it will drain the capacitor through another resistor. Once it drains to a lower threshold it will start over again. This creates an oscillation where the on-time and off-time are set by the two resistors. The chip that we will be using is the 555 Timer IC, which handles the logic of turing on and off the flow of electricity to the capacitor.

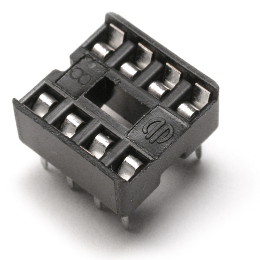
1.3 Additional Components

In addition to the basic components here are the other components that will be used

Figure 7: A 5mm LED

Figure 8: A 555 Timer IC (Integrated Circuit)

Figure 9: An IC Socket

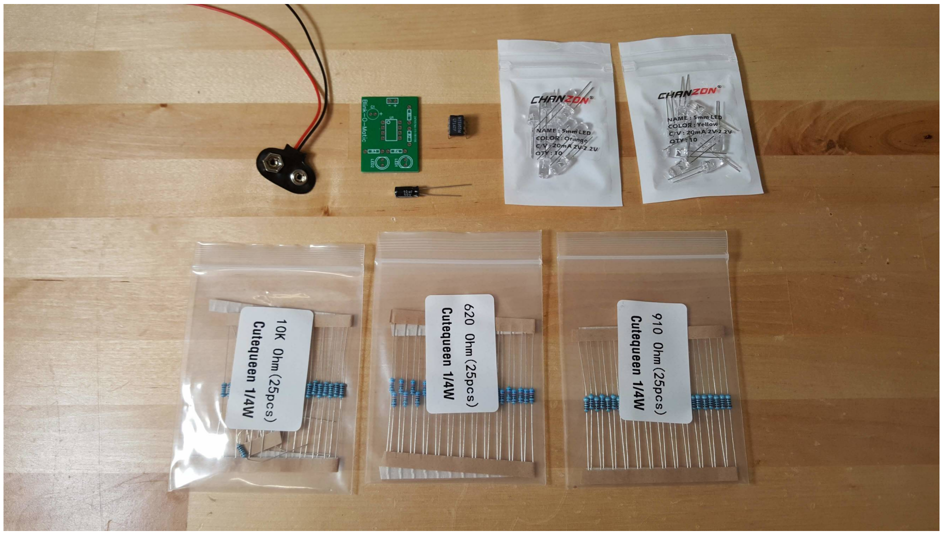


2 Soldering

Here are all the required parts for the workshop,

1. 9V battery snap
2. Printed Circuit Board
3. $10\mu F$ Electrolytic Capacitor
4. 555 Timer IC
5. Two LEDs of any color
6. $1k\Omega$ resistor
7. $10k\Omega$ resistor
8. 2 620Ω resistor
9. 8 pin IC socket(not pictured)

Figure 10: Required Items



Additionally, A Soldering Iron, Solder, and a possibly a circuit board vice (to hold the board) are required.

Figure 11: Tools

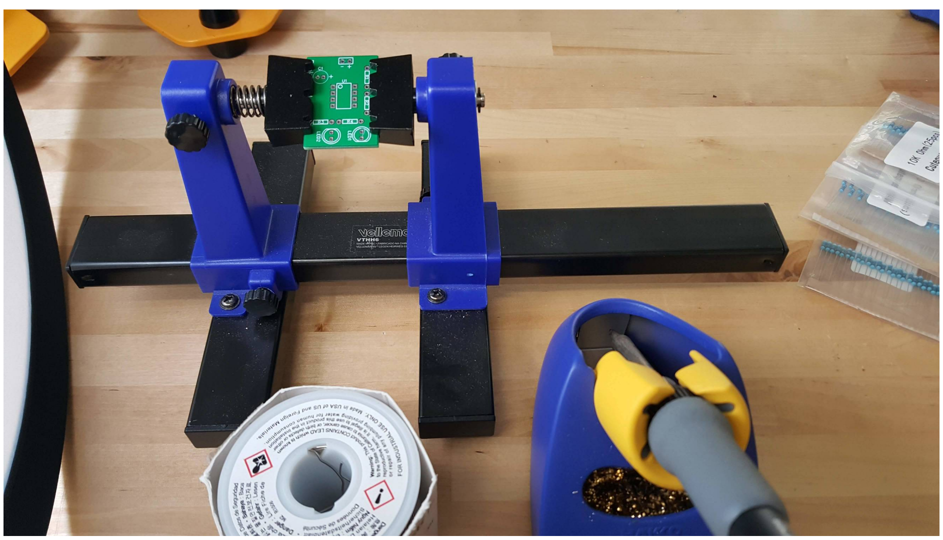
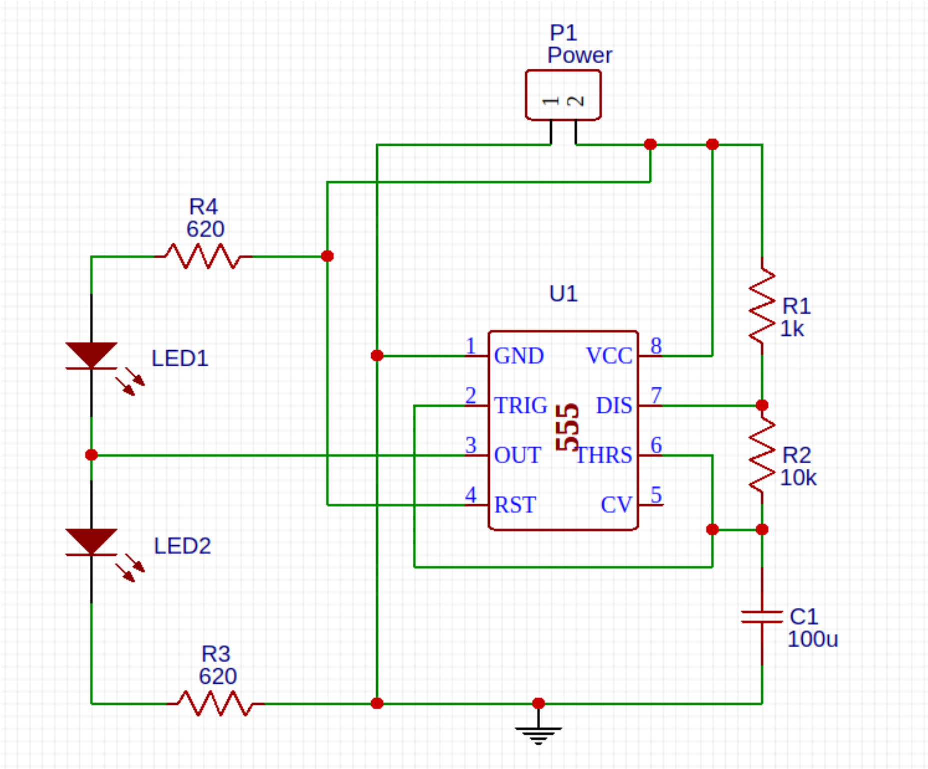
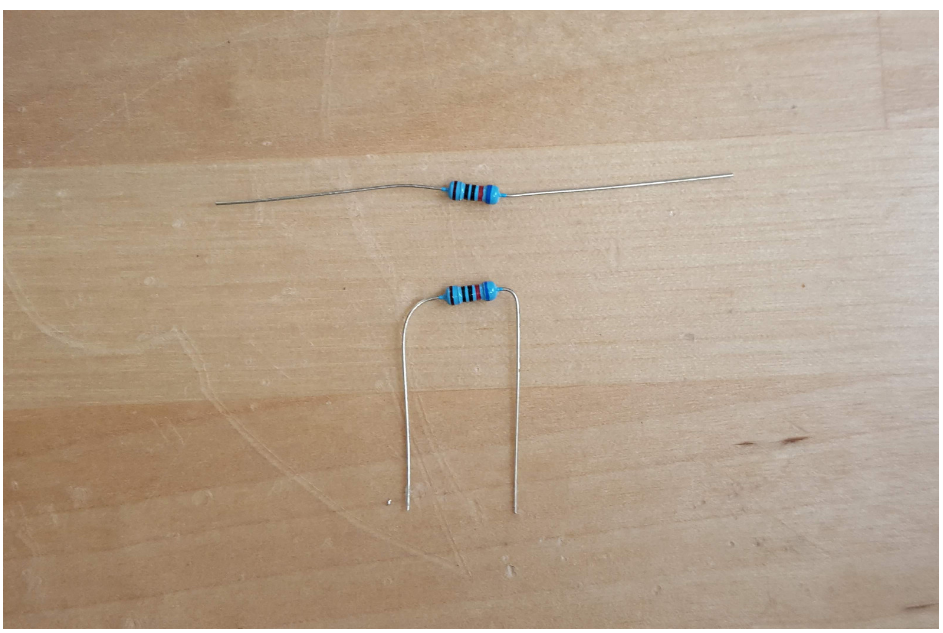


Figure 12: Circuit Schematic for the kit



1. (a) Typically, the best order to place components is in the order of shortest to tallest. We will start with the resistors. The first two resistor we will place are the 620Ω resistors (R3, and R4). Before placing the resistors, bend the leads like this:

Figure 13: Resistor After Bending



(b) Once bent, these will go in the place of R3, and R4. They are inserted into the holes like in the image below.

Note: On this circuit board the holes are a little too close together, making it difficult to position them flat. For the best results, the resistors should lay evenly and a flat to the board.

Figure 14: R3 and R4 Placed on the Board

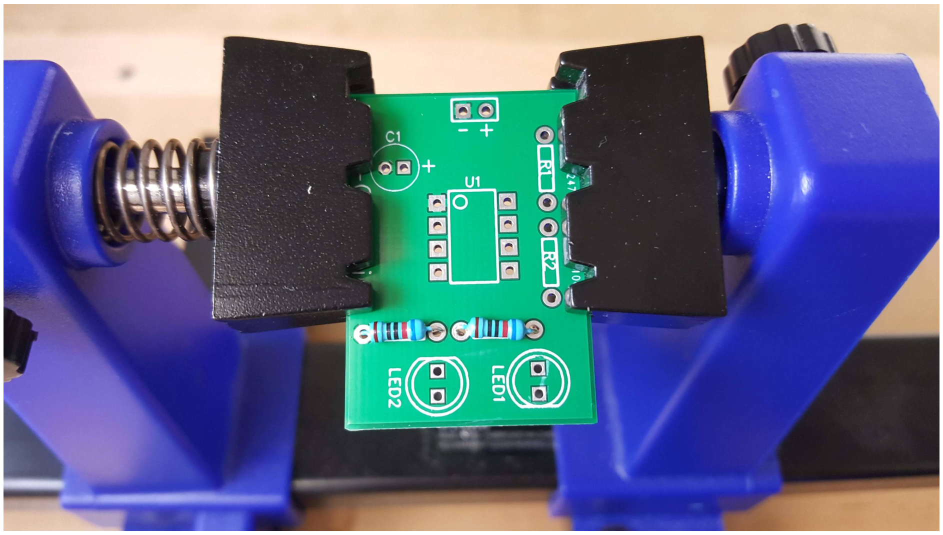
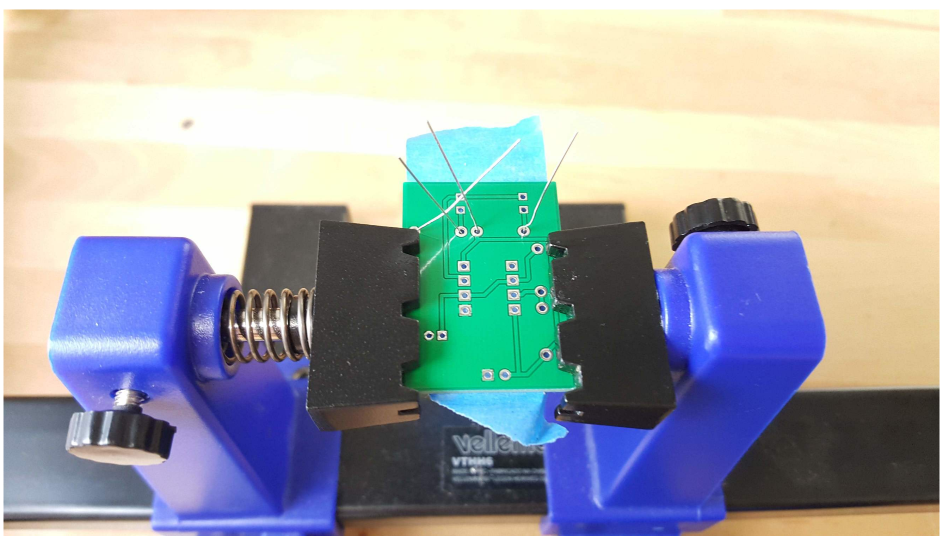
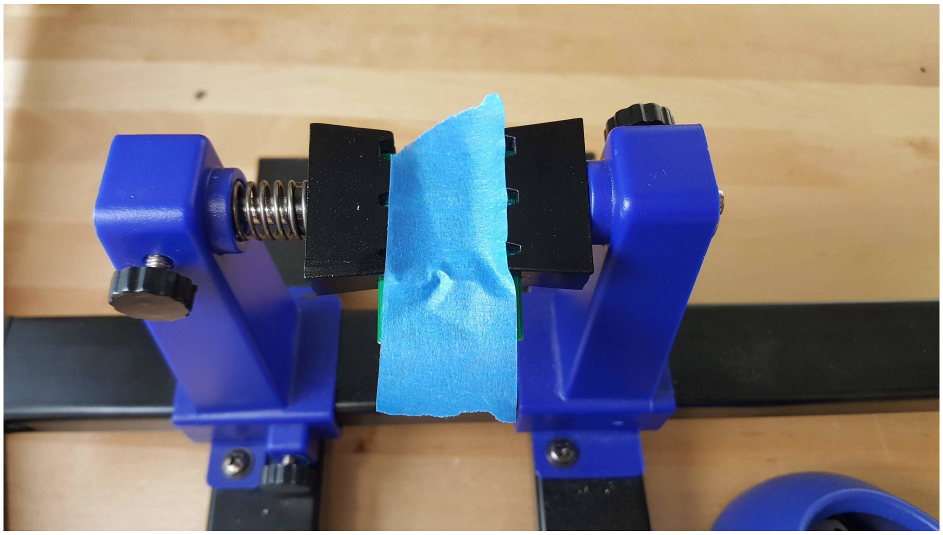


Figure 15: R3 and R4 Placed on the Board (viewed from the bottom side)



(c) It helps to secure the components with a bit of tape to ensure they stay flat to the board while soldering.

Figure 16: Tape Added to Secure Components



2. To begin soldering, the iron should be turned on and allowed to heat. When ready, apply some solder to the tip of the iron (tinning the iron). Then use the brass wool or damp sponge on the stand to clean the tip.

Figure 17: Applying Solder to the Tip

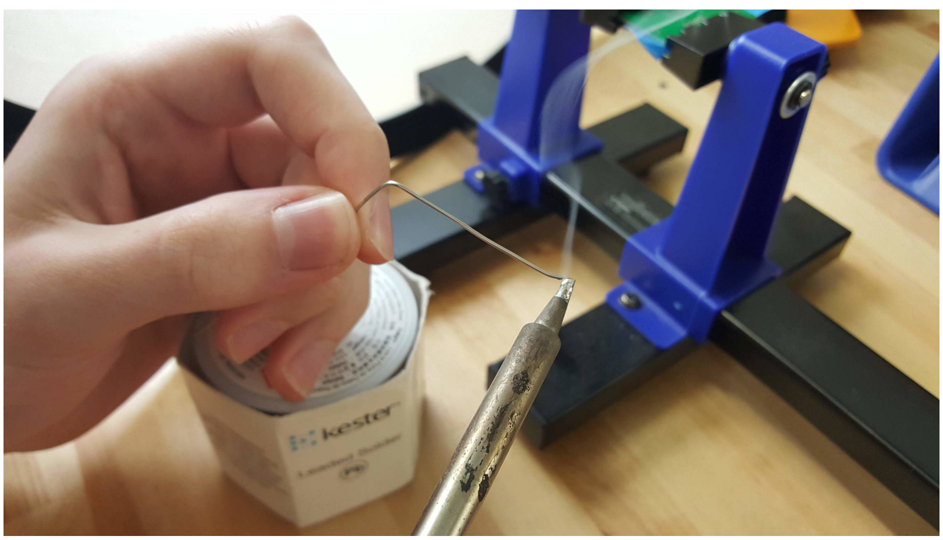


Figure 18: Cleaning the Iron Tip with the brass wool

3. The iron is touched to the resistor's *pad* (the metal ring around the hole). The solder is then pressed against the pad until it flows onto the joint. Once this happens remove the iron and allow it to cool before handling the part. Ideally, you should use just enough solder to make an even cone shape around the wire. The solder should also look shiny, if this is not the case, it is called a cold solder joint. These tend to be more brittle and can be fixed by reheating the joint. However, avoid heating anything for too long. The parts on the board, as well as the circuit board can be damaged by excess heat.

   Note: Applying solder directly to the iron isn't an effective way to solder. Liquid solder gravitates to hotter areas and it will accumulate where the temperature is at a local maximum. Meaning that the solder wont make it to the pad. Instead apply heat to where you want the solder to end up.

Figure 19: The Desired Wire

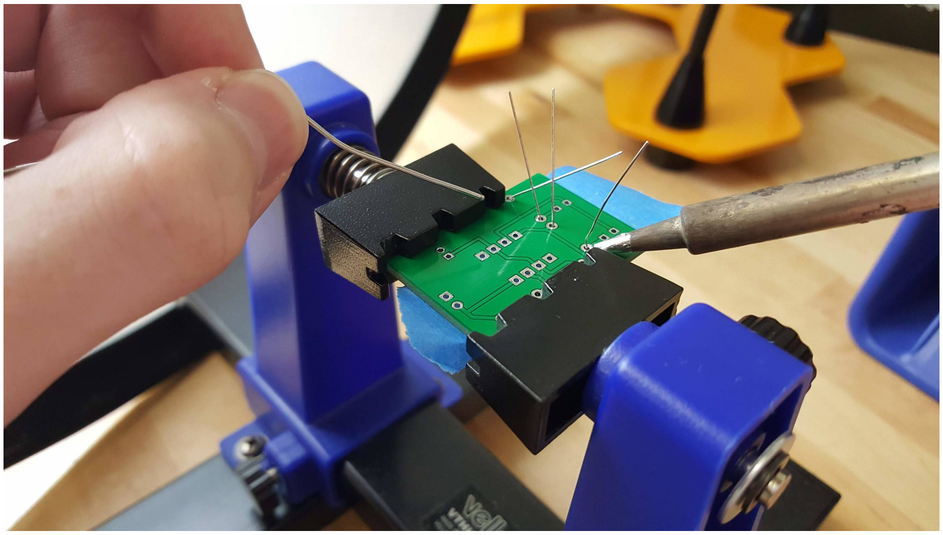


Figure 20: Applying Heat and Solder

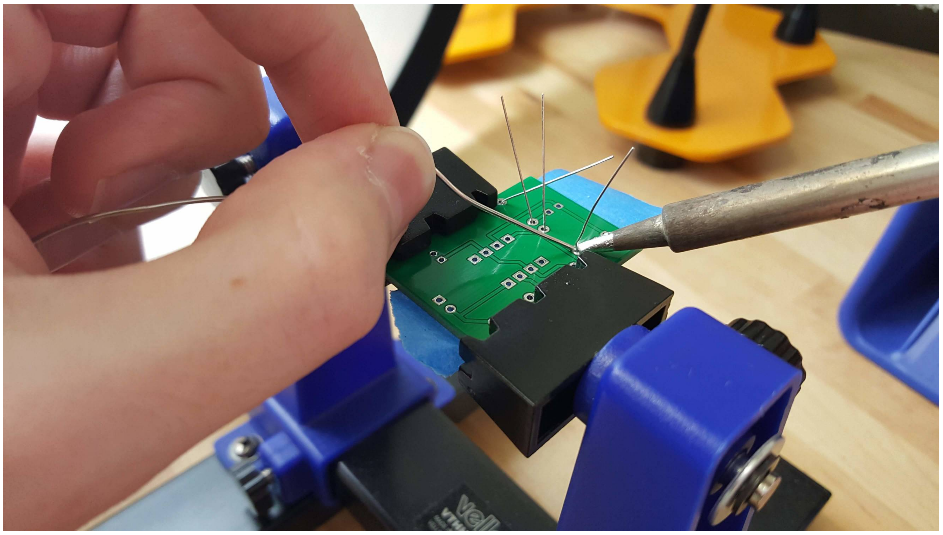
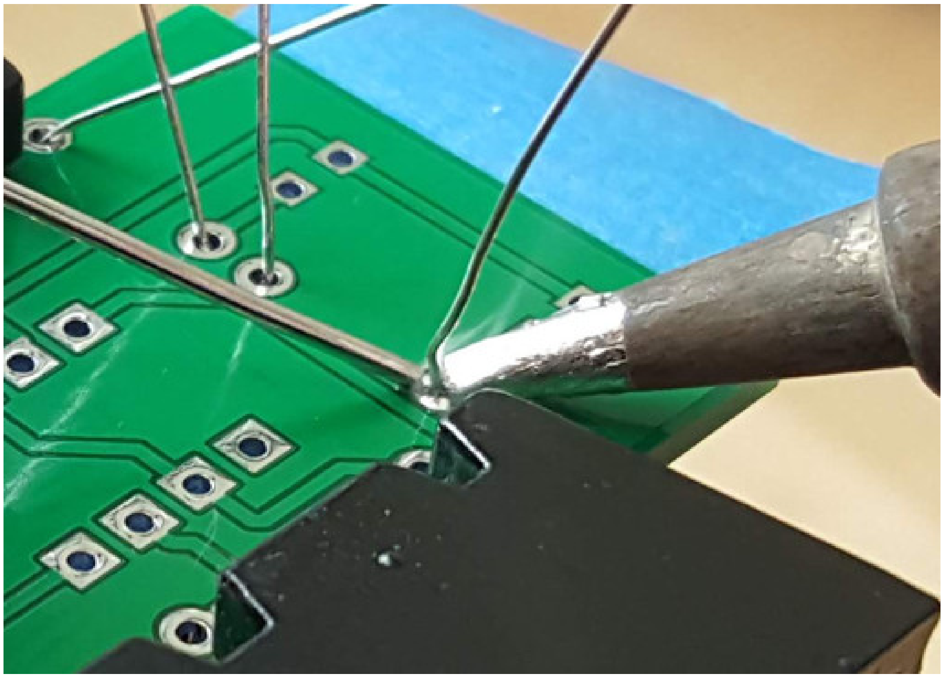
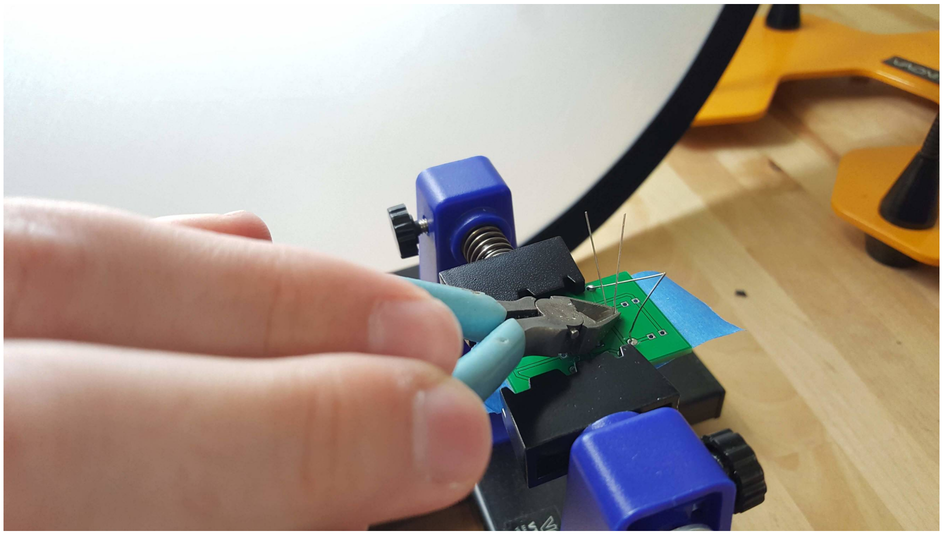


Figure 21: Close Up



4. Next the leads need to be snipped to reduce their length. They can be snipped right where the cone of solder converges to the lead. Be careful, when snipping these leads, they can go flying through the air. Safety glasses are advised throughout this process.

Figure 22: Snipping the Leads



5. The next resistors to solder are R1 ($1k\Omega$), and R2($10k\Omega$). The same steps are repeated for these.

Figure 23: Inserting R1, and R2

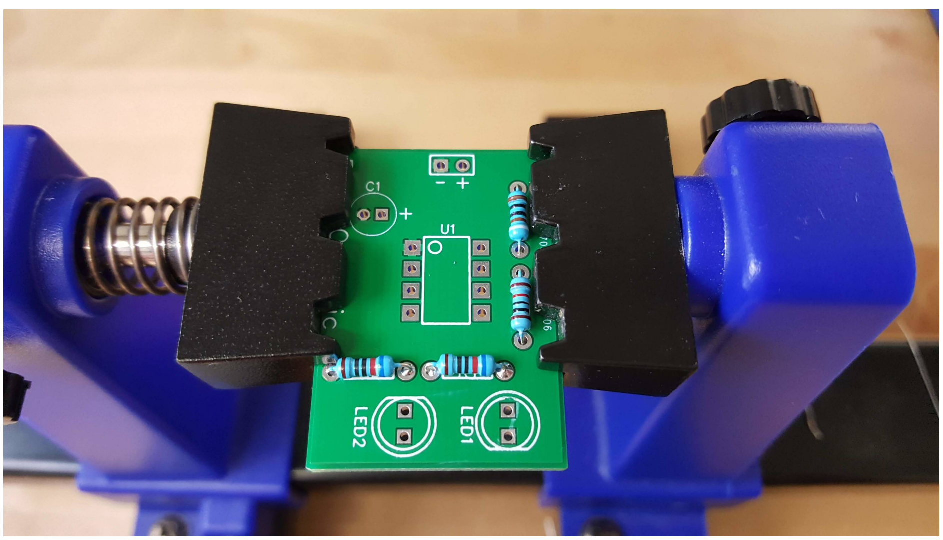


Figure 24: Soldering R1, and R2

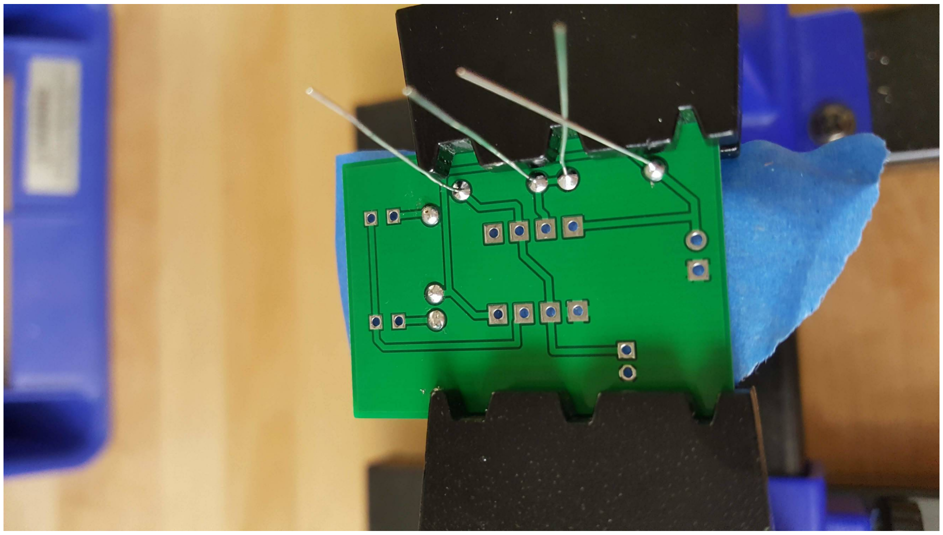
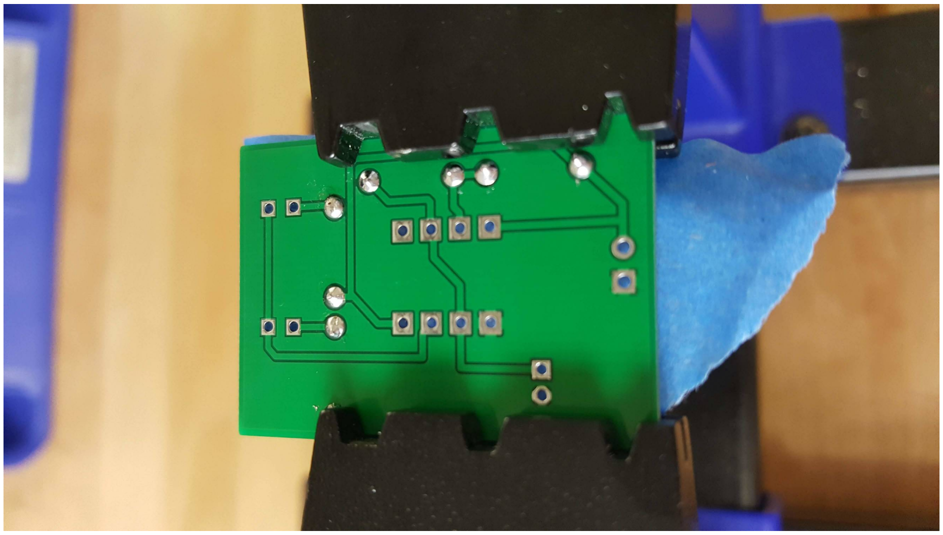


Figure 25: Snipping R1, and R2



6. The integrated circuit can be soldered directly like in the photos, however, it is better practice to use IC sockets. IC sockets are beneficial, because ICs can easily be removed from the circuit if they are damaged. Additionally, the risk of overheating the IC while soldering is negated. The IC typically comes from the factory with leads that are not perfectly 90 degrees. To make it fit, the leads need to be pushed together slightly. The IC and its socket will have a notch to indicate the top of the chip. When placing the IC, ensure that the notch corresponds with the dot on the circuit board.

Figure 26: Bending IC Leads

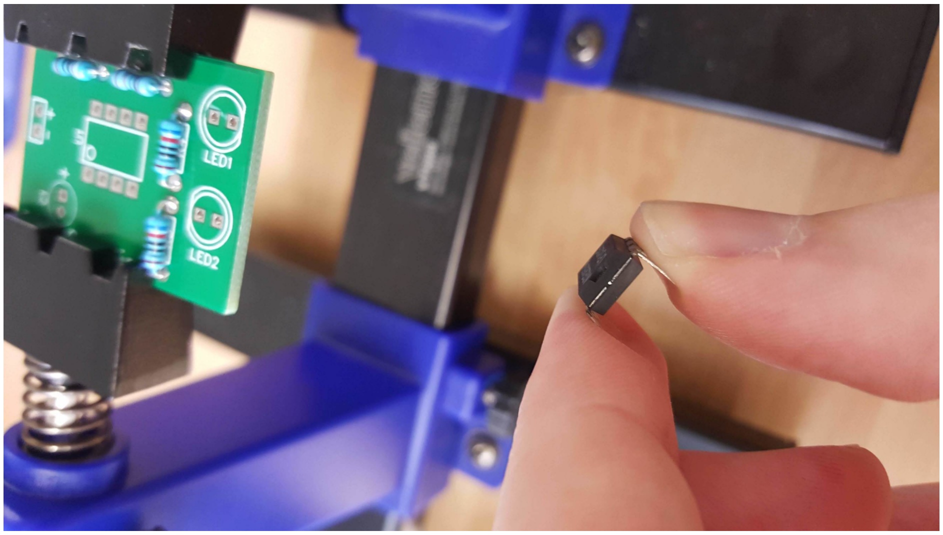


Figure 27: Placing the IC with the Notch Aligned with the Dot

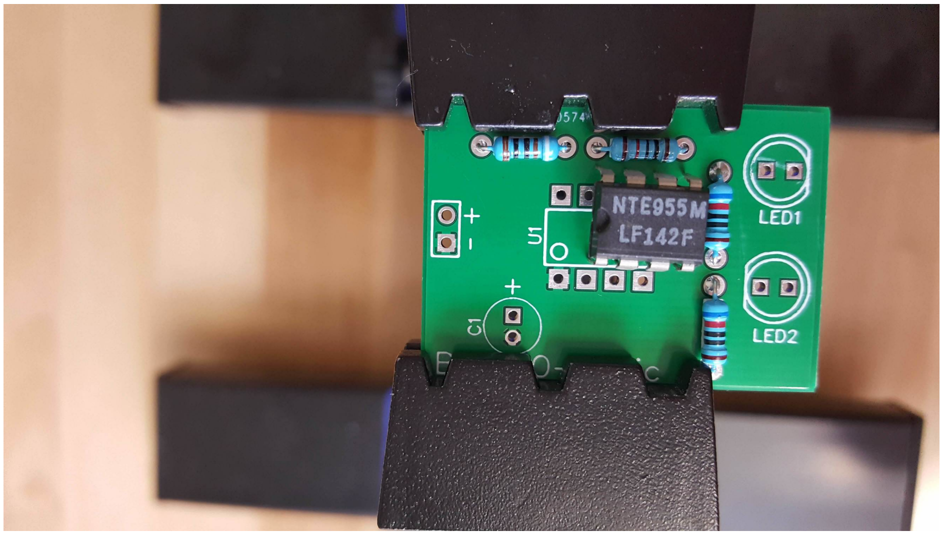
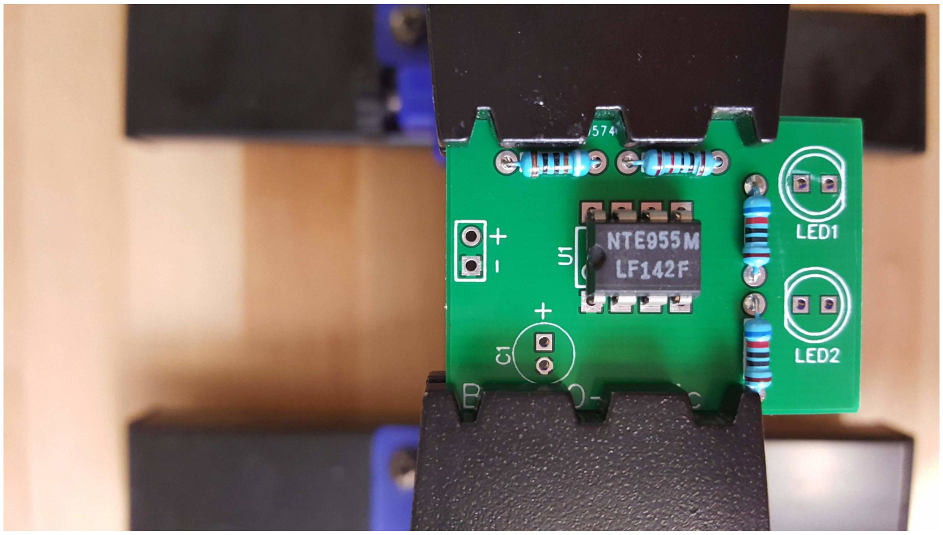


Figure 28: Placing the IC with the Notch Aligned with the Dot



A method that works well for soldering parts with more than two leads, is to first tack one lead down then put pressure on the part to flatten it while brefly applying heat to the joint. This allow the part to be placed as straight as possible. Once it is in the desired spot, the remaining pins can be soldered.

Figure 29: One lead being soldered

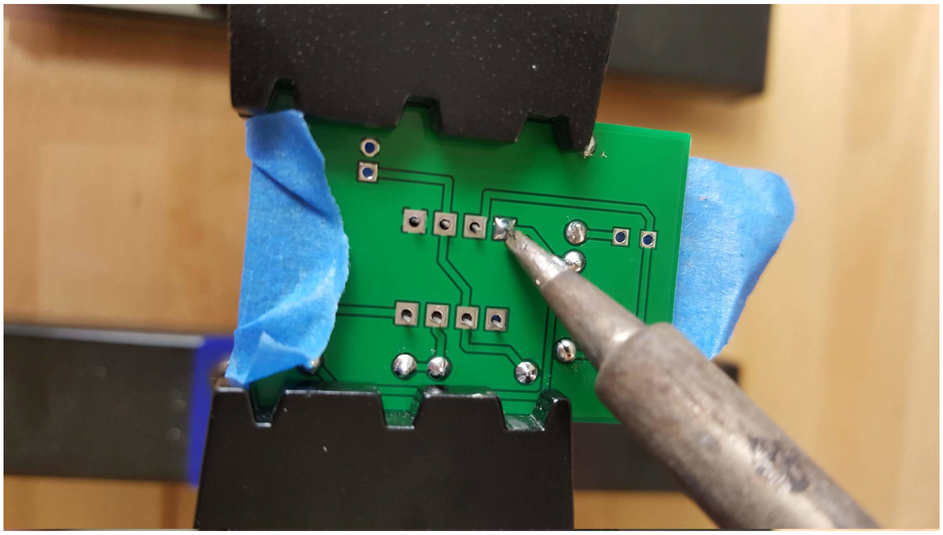


Figure 30: IC being adjusted

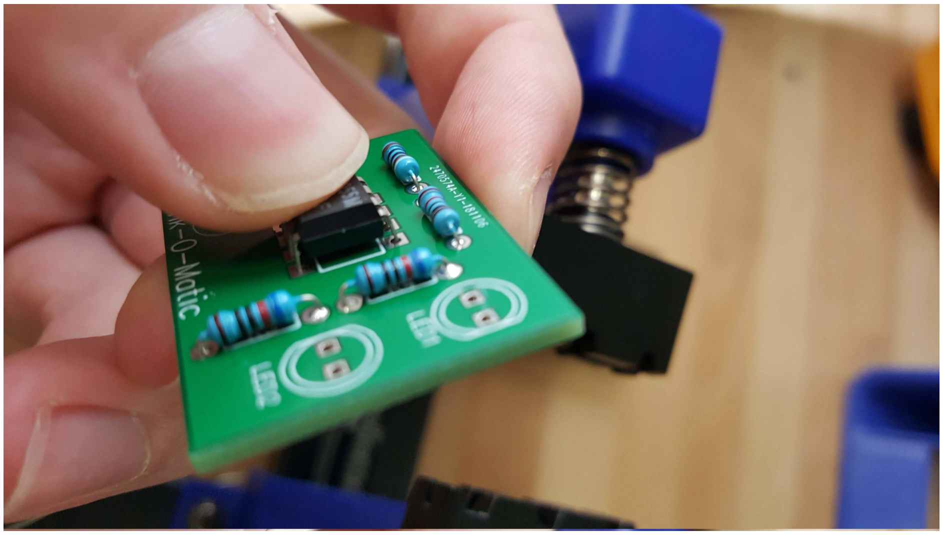
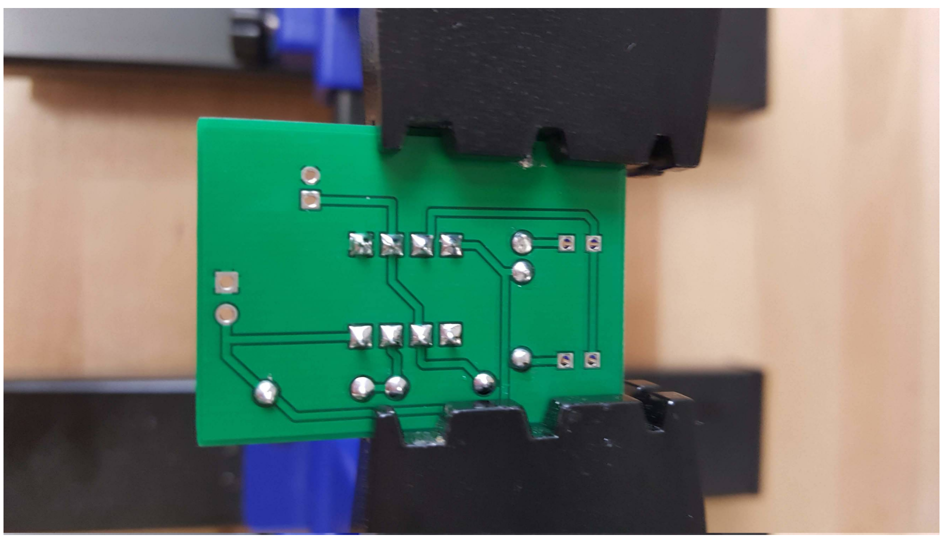


Figure 31: Remaining pins soldered



7. Now capacitor C1 needs to be soldered. Since these capacitors are polarized they need to be inserted in the correct orientation. On the package for the capacitor, it is labeled with a negative sign to indicate the negative lead. Also the other lead (the positive lead) is longer. When placing it on the board ensure that the positive lead goes in the hole labeled with the plus sign. Once the capacitor is in its place, solder it and then snip the leads.

Figure 32: Electrolytic Capacitor (note the negative strip and the longer positive lead)

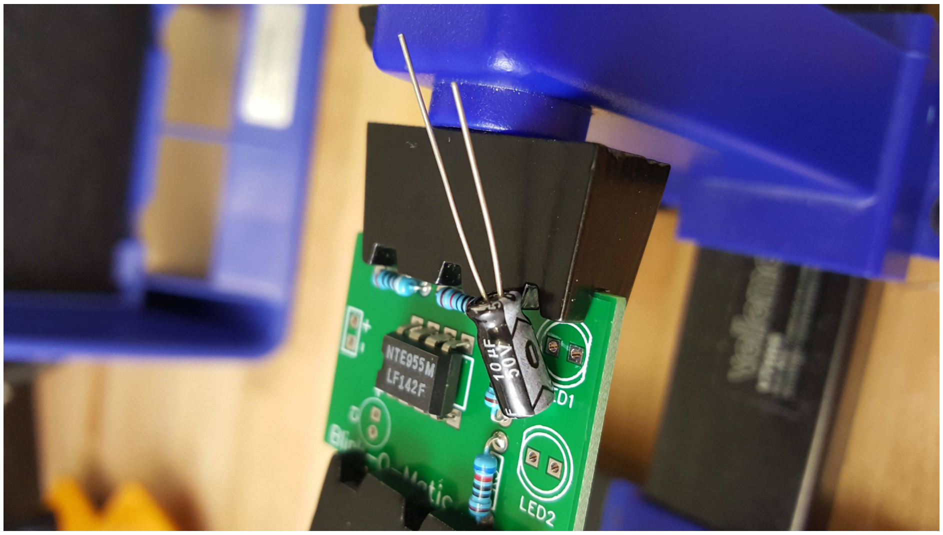


Figure 33: Inserting C1 (being careful of polarity)

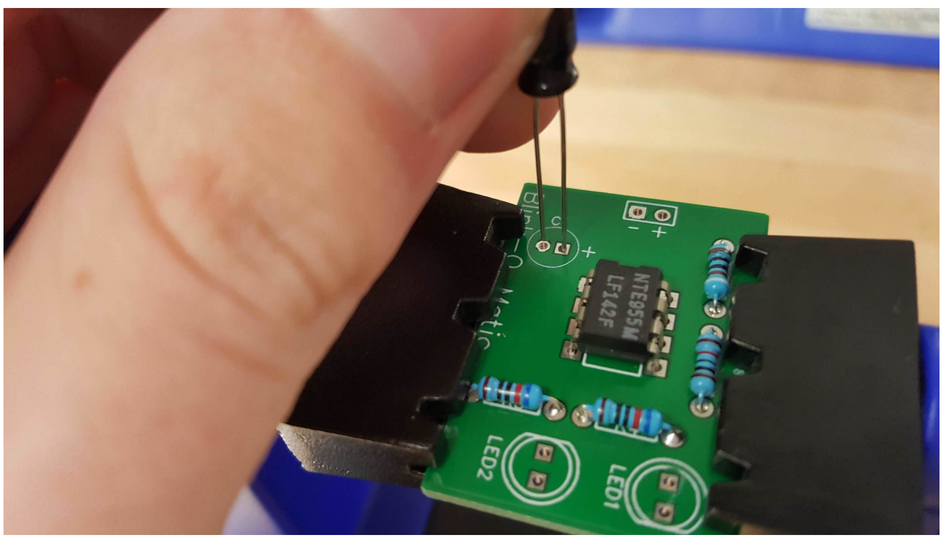


Figure 34: C1 in its Place

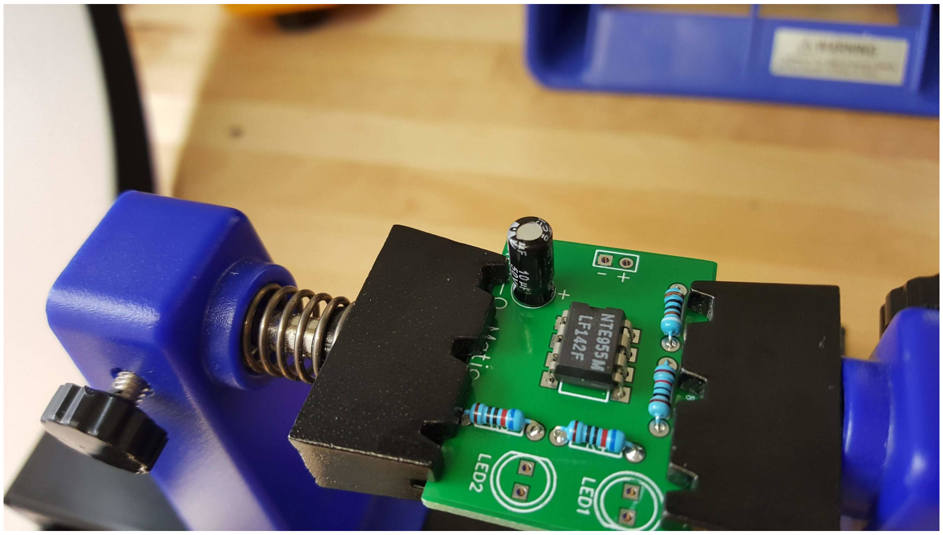
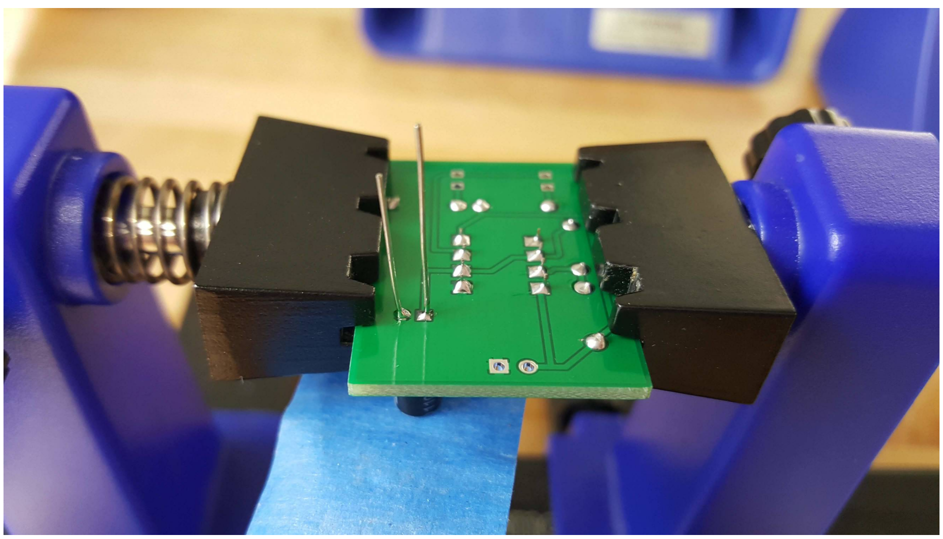


Figure 35: Soldering C1



8. Next, the LED is soldered. LEDs are also polarized so their orientation matters. The LED will have a flat edge that indicates the negative lead, and the same longer positive lead. The circuit board has the outline of the LED, align the flat edge of the LED with the flat edge on the outline. Do this for both LEDs then solder them and snip their leads.

Figure 36: LED (note the flat side indicating negative and longer positive lead)

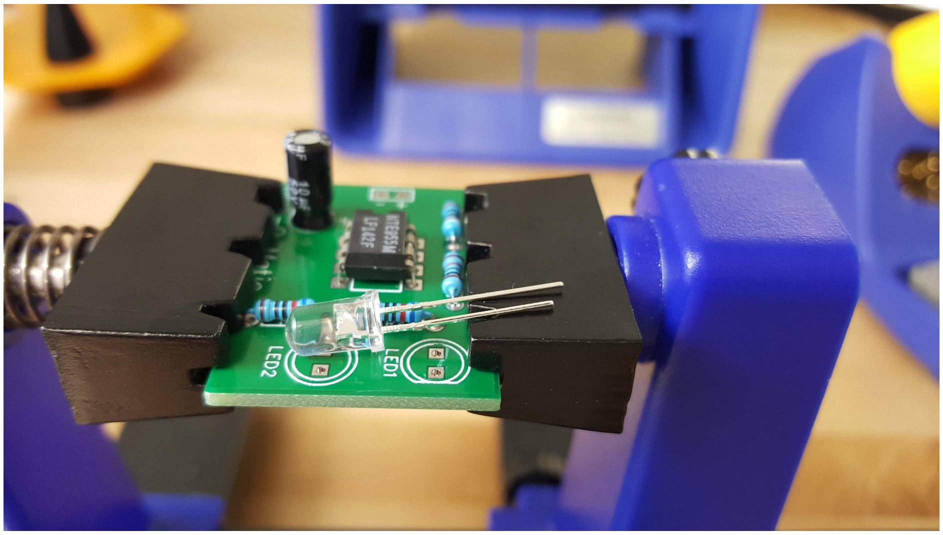


Figure 37: Inserting LED (being careful of polarity)

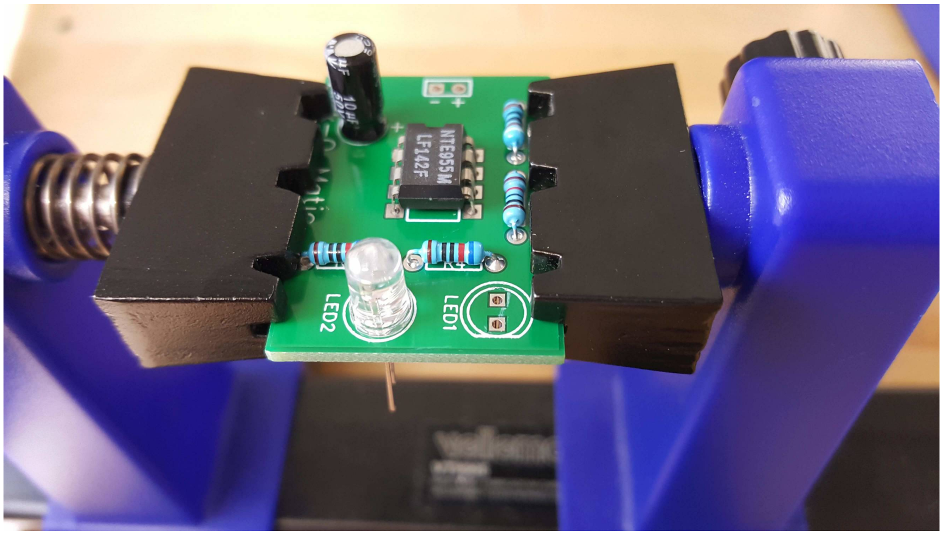


Figure 38: Both LEDs in Place (they are oriented opposite from each other)

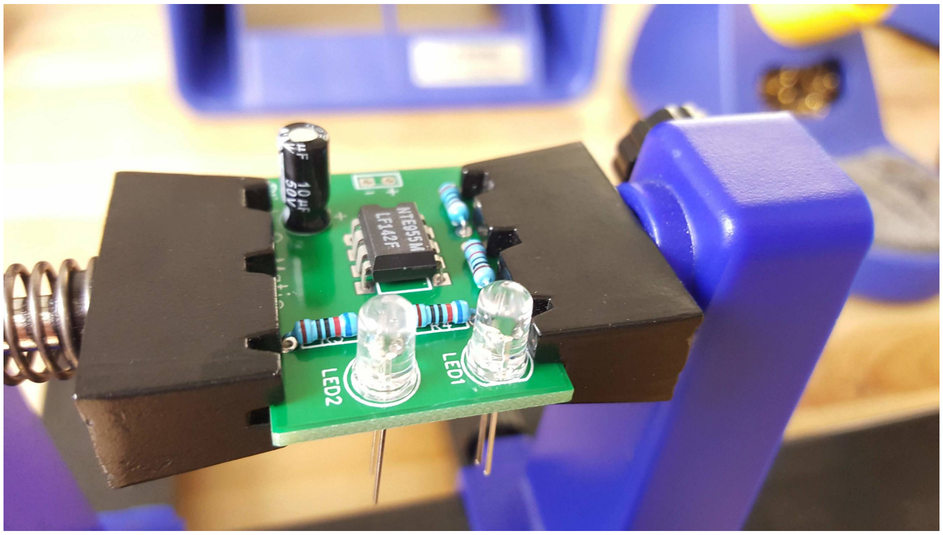
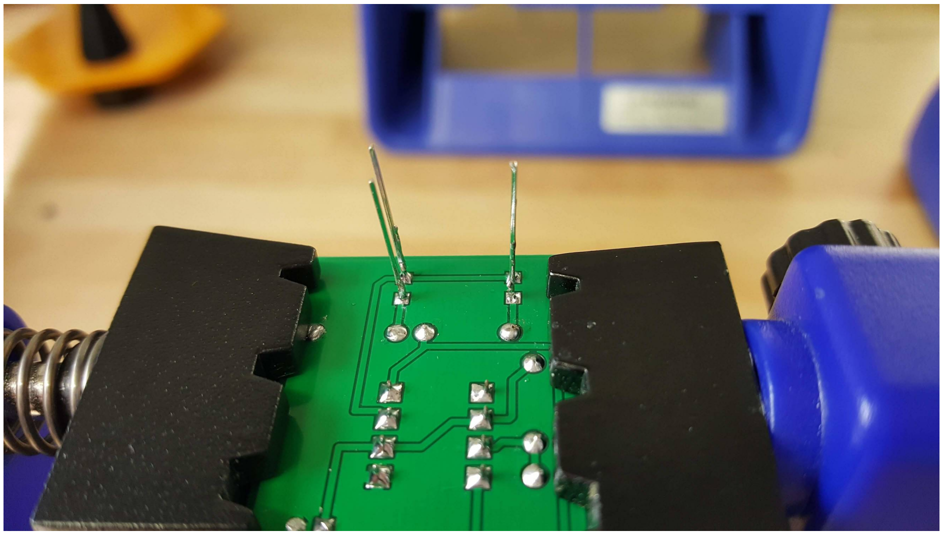


Figure 39: Both LEDs Soldered



9. Finally, The 9V battery snap is soldered. Insert the red wire into the hole labeled with the plus sign, and the black to the one with the negative sign. Solder the wires in, and then snip the leads.

Figure 40: Battery Snap Leads in place

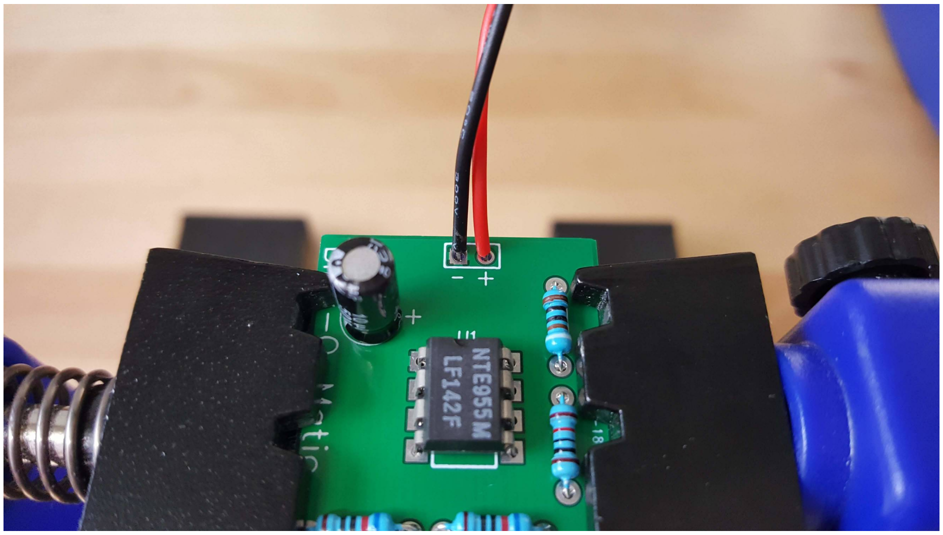
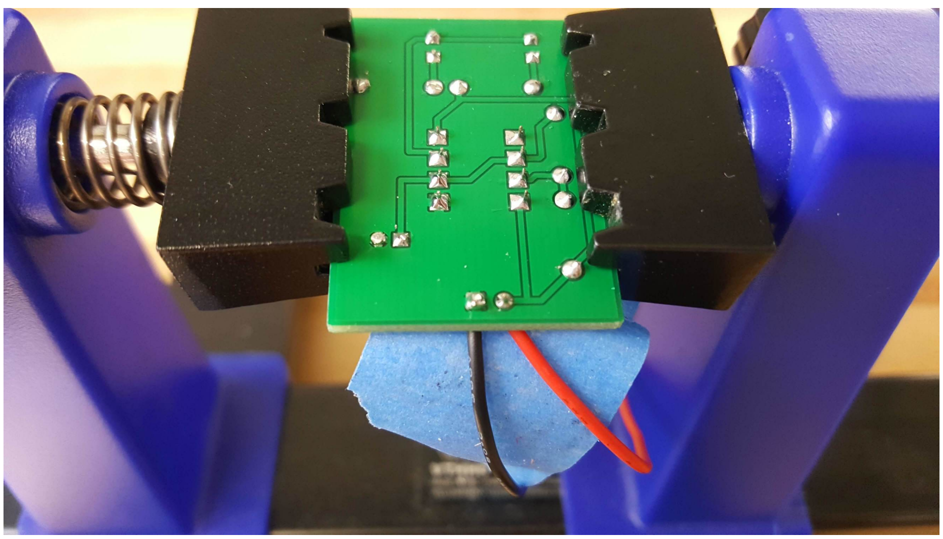


Figure 41: Battery Snap Soldered



10. Now the kit is finished and can be powered with a 9v battery.

Figure 42: Finished Kit