# Wireless I/O Board
# Build Instructions

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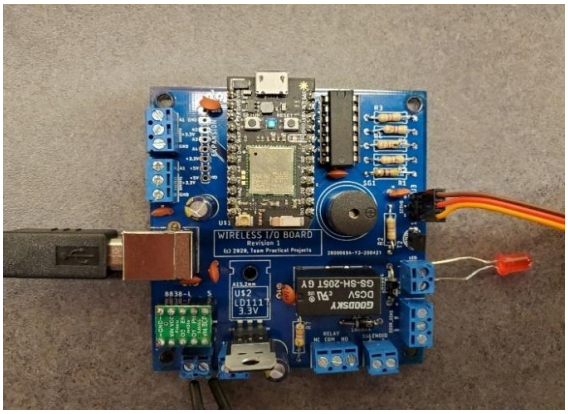
https://github.com/TeamPracticalProjects/Wireless_IO_Board/blob/master/Terms_of_Use_License_and_Disclaimer.pdf



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# 1. OVERVIEW.

This document provides instructions for assembling the *Wireless I/O Board*. The *Wireless I/O Board* provides many different functions and it is only necessary to load those parts on the board that you need for the functionality that you desire. The "Wireless_IO_Board_User_Manual" in this repository contains further information about the various functions of the *Wireless I/O Board.*

Section 2 of this document shows which components are required for specific functionality of the *Wireless I/O Board.* Section 3 of this document contains assembly instructions and helpful hints for assembling components on the *Wireless I/O Board.*

# 2. FUNCTIONAL ASSEMBLY GUIDE.

This section is a guide to which components are needed to be loaded onto the *Wireless I/O Board* in order to provide various functions. The components shown in section 2.1 are required for any and all functions of the *Wireless I/O Board*. Subsequent subsections show which additional components are required for specific functions of the *Wireless I/O Board.* Mixing and matching of these various subsections can provide any combination of functions required by the user.

## 2.1. Core Components.

Figure 2-1 shows those components of the *Wireless I/O Board* that are necessary for any and all functions that the board can perform. A description of these components follows.

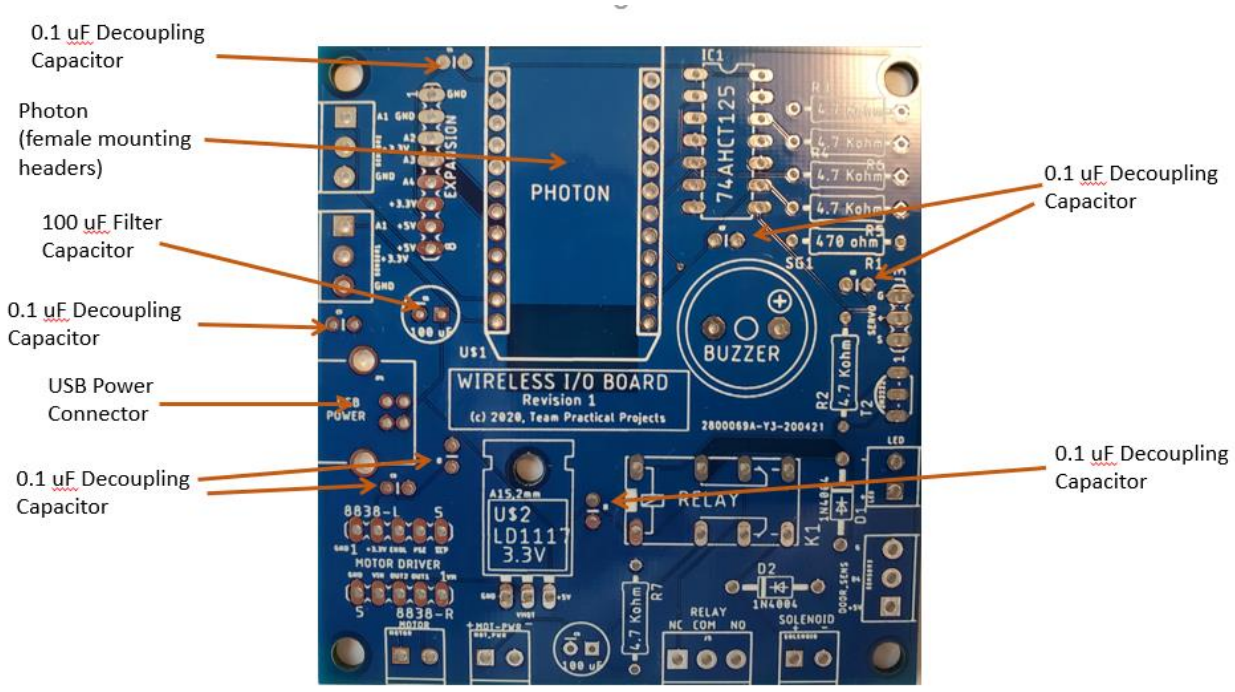


*Figure 2-1. Core Components*.

## Photon.

The Particle Photon is the main component of the *Wireless I/O Board*. It provides the "brains" of the board as well as WiFi connectivity to control and status the board. The Photon is mounted to the board using two 12-pin female headers as a socket. See section 3 for assembly details.

## USB Power Connector.

A type-B USB connector must be soldered onto the *Wireless I/O Board*. This connector is used to source 5 volt power onto the board. The Photon's micro-USB connector can also be used to power the board, but the separate type-B connector relieves wear on the Photon. The type-B USB connector only provides power; it does not provide USB signaling. The Photon's micro-USB connector must be used if serial I/O or other USB signaling to the Photon is required. It is safe to connect the Photon micro-USB connector to an external computer while this type-B USB connector is being used to externally power the *Wireless I/O Board*.

## 100 uF Filtering Capacitor.

This capacitor provides bulk, low frequency filtering of the 5 volt power supplied to the *Wireless I/O Board* via the type-B USB connector (or via the Photon's micro-USB connector). This

capacitor should always be soldered to the board to ensure that low frequency noise from the power supply is filtered out from the board.

### 1.1 uF decoupling capacitors.

All seven 0.1 uF decoupling capacitors should always be soldered onto the *Wireless I/O Board*. These capacitors decouple high frequency switching spikes from adversely affecting the digital circuit components on the board. It is best practice to solder all of these capacitors to the board even if only a few digital circuit components are used.

## 2.2. Small Motor Controller Parts.

Figure 2-2 shows those additional parts that should be soldered to the *Wireless I/O Board* in order to control a small DC motor via firmware on the Photon. These are in addition to the Core Components that must always be present on the board. Photon pin D2 controls the motor direction and Photon pin D3 activates the motor (PWM to control the motor speed). A description of these components follows.

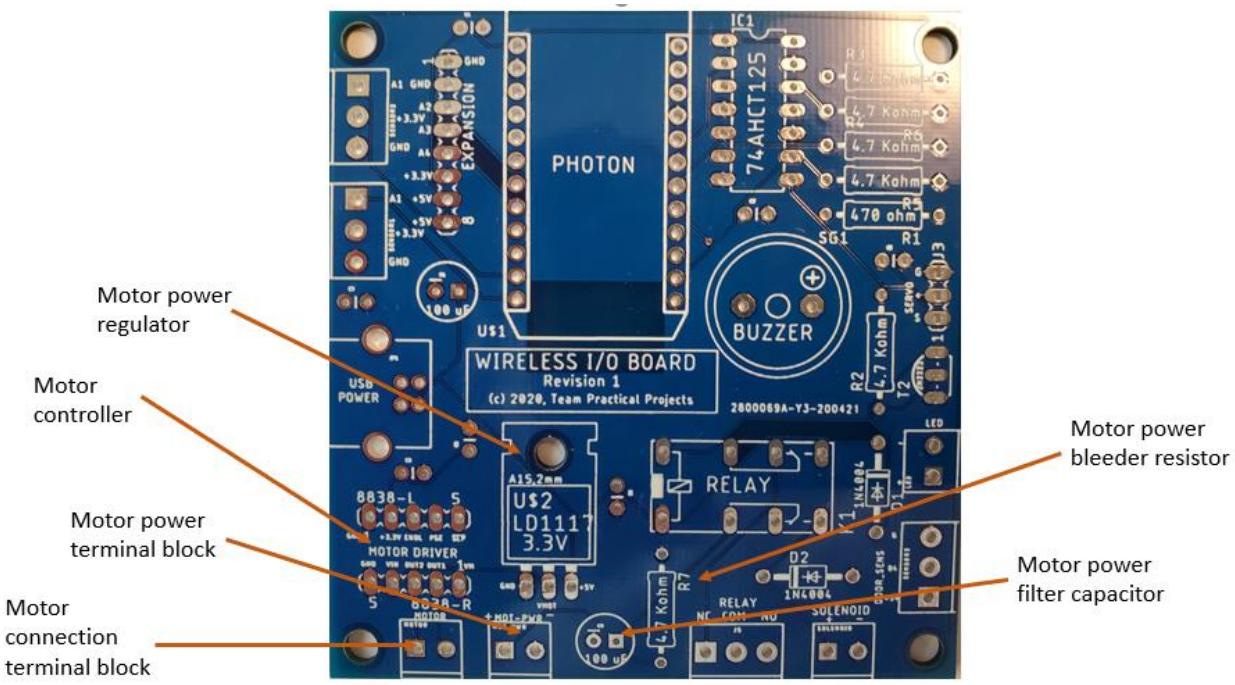


*Figure 2-2. Small DC Motor Components.*

## Motor Controller.

A Pololu DRV8838 small DC motor controller module provides logic control of a motor's speed and direction. The logic portion of this module operates off of the Photon's 3.3 volt logic supply, while the motor has an independent (of the Photon) power supply. The DRV8838 motor controller module must have male header pins soldered onto it and is then connected to *Wireless I/O Board* via two, 5-pin female headers.

## Motor Connection Terminal Block.

This 2-position terminal block is where the two leads from a small DC motor are connected to the *Wireless I/O Board.*

## Motor Power Terminal Block.

This 2-position terminal block is where an external motor power supply can be connected to the *Wireless I/O Board. If an external power supply is used to power the motor, the LD1117 power regulator should not be soldered onto the board.* Alternatively, if the LD1117 power regulator is included on the board, then this terminal block provides a motor power output from the board. If the LD1117 power regulator is used to power the motor and if this motor power is not required anywhere else in your project, then this Motor Power Terminal Block need not be soldered onto the board.

## LD1117 Voltage Regulator.

This component is used to provide an on-board source of 3.3 volt power to an external motor. This regulator steps 5 volt input power (to the board) down to 3.3 volts for use by a 3 volt motor. The Photon's internal 3.3 volt regulator is not used to power the motor. If an external source of motor power is used, this regulator should not be used on the board.

## Motor Power Filter Capacitor.

This 100 uF filter capacitor is needed to provide output power filtering to the LD1117 voltage regulator. It must be used if the LD1117 voltage regulator is used to provide motor power. This capacitor may also be used if external motor power requires filtering near the motor controller.

## Motor Power Bleeder Resistor.

Provision is made to solder a 4.7 Kohm (or other value) bleeder resistor to the *Wireless I/O Board.* This resistor provides a constant small load for the LD1117 voltage regulator even when the motor is not running. It also discharges the 100 uF filter capacitor when the board is not

powered. This resistor is required when the LD1117 voltage regulator is used. It may or may not be required when an external motor power source is used.

## 2.3. Relay/Solenoid Control Parts.

The *Wireless I/O Board* contains a small, 2P2T relay. One pole of this relay is wired to control a solenoid or load that is powered by the Small DC Motor power (either internal via the LD1117 or externally supplied). A flyback diode is provided on the board for inductive loads. The load can then be wired directly to the terminal block provided on the board.

The second pole of the relay is simply connected to a terminal block which provides Common, NO and NC contacts directly to off-board components. Anything connected to these terminals must be externally powered and protected.

Photon pin D0 activates the relay when set to HIGH.

Figure 2-3 shows those additional parts that should be soldered to the *Wireless I/O Board* in order to control the relay via firmware on the Photon. Note that there is only one relay on the board that effects both poles simultaneously. The components shown in figure 2-3 are in addition to the Core Components that must always be present on the board. In addition, the LD1117 voltage regulator, 100 uF filtering capacitor, bleeder resistor and (optionally) Motor Power Terminal Block may need to be added if the board is to provide power for the external solenoid or other load – see section 2-2 for details). A description of these components follows.

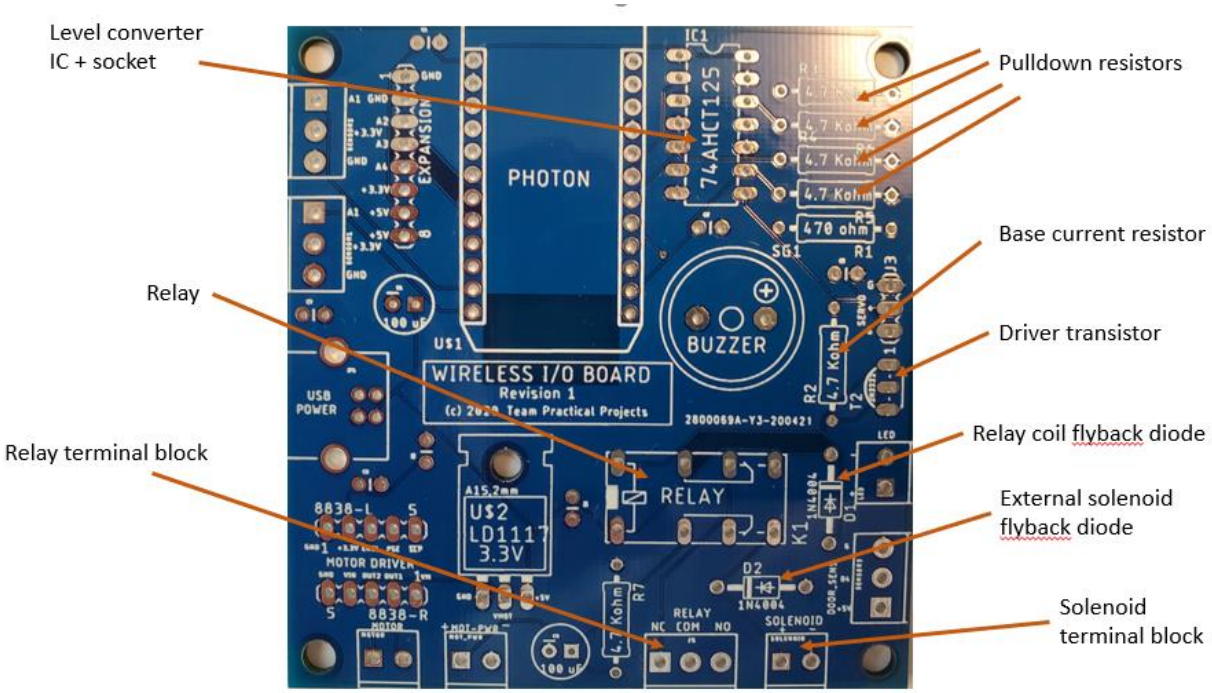

*Figure 2-3. Relay/Solenoid Components*.

## Internal/External Load Power.

If the LD1117 voltage regulator is to be used to power an external solenoid or other load, then the LD1117, 100 uF filter capacitor and the bleeder resistor should be mounted, as described in section 2.2. If an external load power supply is used, then the Motor Power Terminal Block should be soldered to the board, as described in section 2-2. In either event, the Motor Controller and the Motor Connection Terminal Block are not required if the motor controller capability is not used.

## Level Converter IC and Socket.

A 74AHCT125 non-inverting driver is used to convert Photon signals for driving the relay (via a transistor amplifier). This 14 pin IC is mounted to the *Wireless I/O Board* via an IC socket. Note that this IC is used to convert logic signals for several functions of the board and it must be provided if any of these functions are to be used.

## Pulldown Resistors.

Four 4.7 Kohm resistors are used to pull down the logic inputs to the Level Converter IC when the Photon is being powered or reset. While only one signal line is used to control the on-board relay, it is recommended that all 4 pull down resistors be soldered to the *Wireless I/O Board* whenever the Level Converter IC is used.

## Base Current Resistor and Driver Transistor.

These components amplify the logic signals to drive the coil of the on-board relay. The resistor value is 4.7 Kohms and the transistor is a 2N2222 bipolar NPN device.

## Relay.

The on-board relay must be soldered to the *Wireless I/O Board.*

## Diodes.

Two 1N4004 diodes must be soldered to the *Wireless I/O Board.* One diode acts as a flyback for the relay coil and the other diode is a flyback for the external load. If the external load is resistive, then the External Solenoid Flyback Diode may be omitted but the Relay Coil Flyback Diode is still required.

### Solenoid Terminal Block.

This 2-position terminal block is used to connect an external solenoid or other load to the *Wireless I/O Board.* It provides switched power from the Relay to the external load.

### Relay Terminal Block.

This 3-position terminal block provides external access to the second pole of the on-board relay. The relay's COMMON, Normally Open (NO) and Normally Closed (NC) contacts are provided to external circuits via this terminal block.

## 2.4. Servo Control Parts.

The *Wireless I/O Board* provides the capability to drive a 5 volt hobby servo from Photon pin D1. Figure 2-4 shows the additional parts (over and above the Core parts) that must be soldered to the *Wireless I/O Board* in order to control an external servo. A description of these components follows.

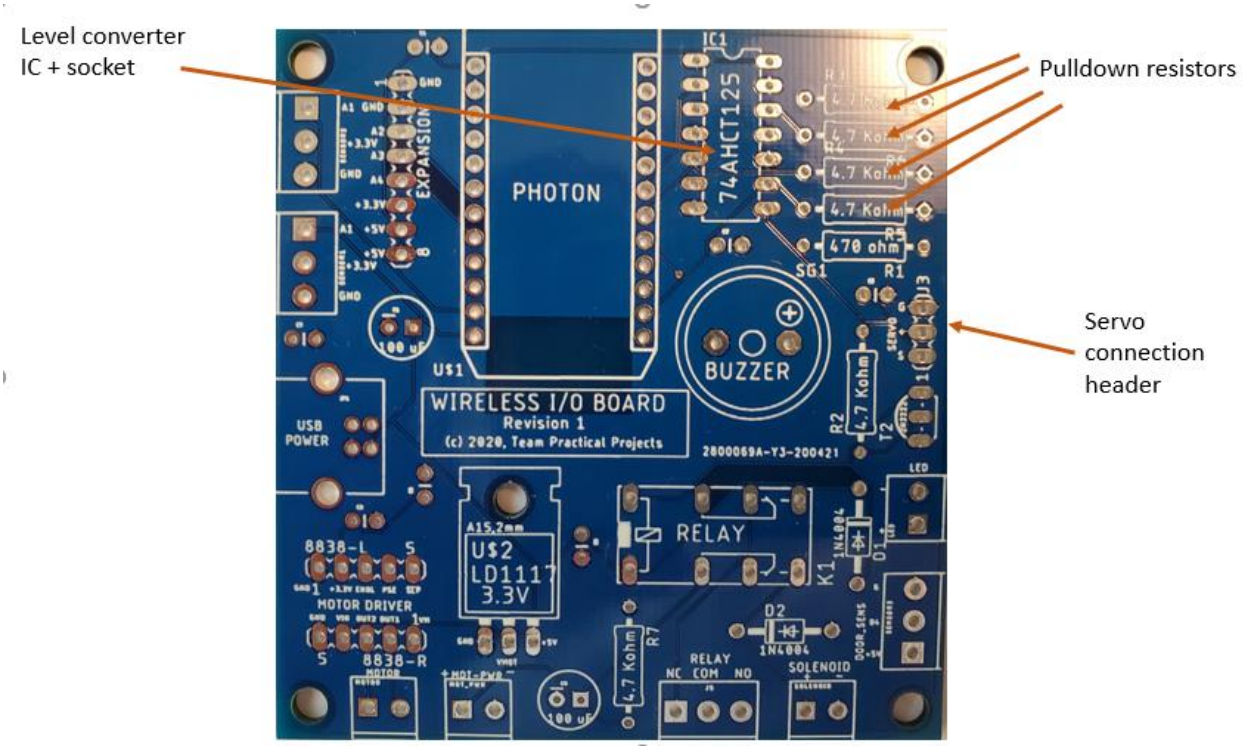


*Figure 2-4. External Hobby Servo Parts.*

### Level Converter IC, Socket, and Pulldown Resistors.

These components must be soldered to the *Wireless I/O board* as described in section 2.3, above.

### Servo Connection Header.

This 3-pin male pin header is wired to directly accept the female connector from a standard hobby servo. The connector provides +5 volts, ground, and the servo signal (level converted to 5 volts). Photon pin D1 is used to command the servo.

## 2.5. Buzzer/External LED Parts.

The *Wireless I/O Board* contains an on-board piezo buzzer and has provision to directly connect an external LED to the board. The buzzer and the external LED are activated by different pins on the Photon, so either or both of these functions can be used. An on-board current limiting resistor allows an external LED to be directly connected to the board. This resistor can be bypassed (with a wire) to provide a general purpose 5 volt level logic output from the board.

Figure 2-5 shows those additional parts that should be soldered to the *Wireless I/O Board* in order to control the on-board buzzer and an external LED. A description of these components follows.

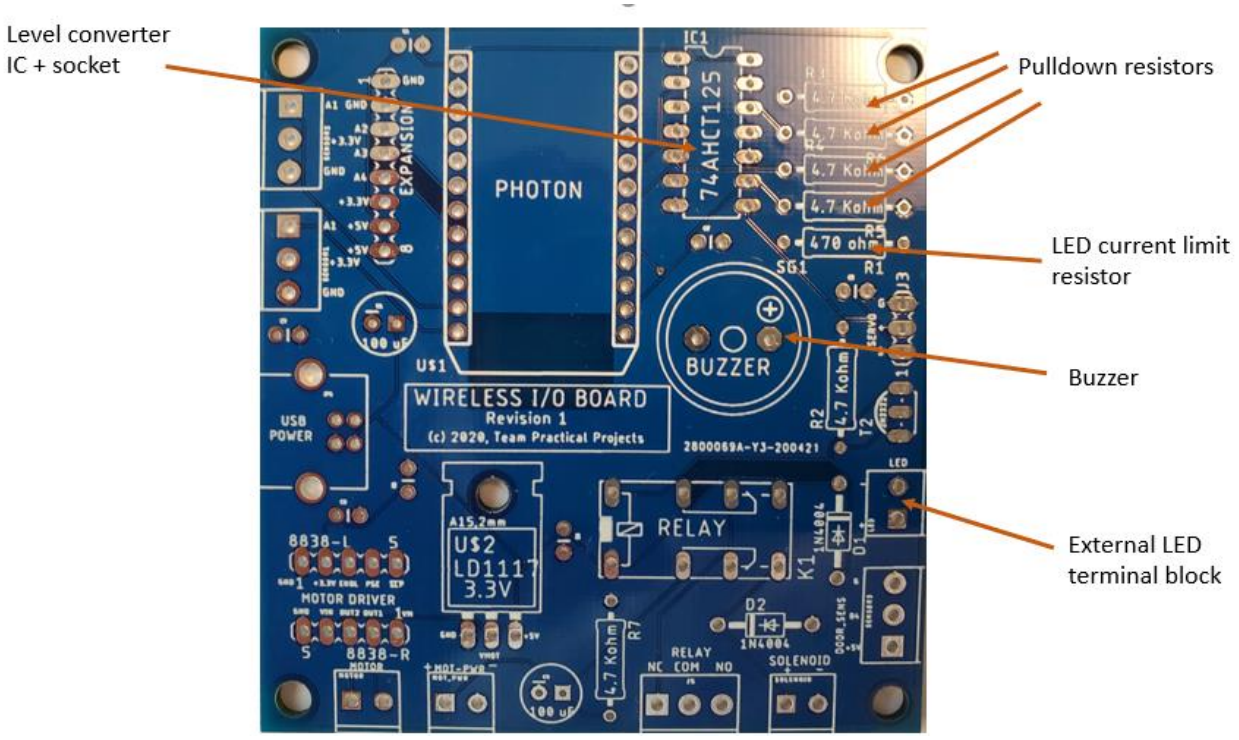

Figure 2-5. Buzzer and External LED Components.

### Level Converter IC and Socket / Pulldown Resistors.

These components must be soldered to the *Wireless I/O board* as described in section 2.3, above.

### Buzzer.

A piezo buzzer may be soldered onto the *Wireless I/O Board*. The buzzer is activated by setting Photon D6 to HIGH.

### LED Current Limit Resistor and LED Terminal Block.

A current limiting resistor (R1) can be soldered to the *Wireless I/O Board.* This allows an external LED to be connected to the LED Terminal Block without any other external components. A 470 ohm resistor provides about 6 ma of current through a typical LED, which is bright enough for most purposes. The Terminal Block is marked with the proper LED polarity. A piece of wire can be soldered to the *Wireless I/O Board* in place of the resistor providing a 5 volt digital output signal for general purpose use (8 ma max). The LED/digital output is controlled by Photon D5.

## 2.6. General Analog and Digital I/O Parts.

Three, 3 position terminal blocks are provided for general purpose I/O use. Figure 2-6 shows these terminal blocks, which may be soldered onto the *Wireless I/O Board* as needed.

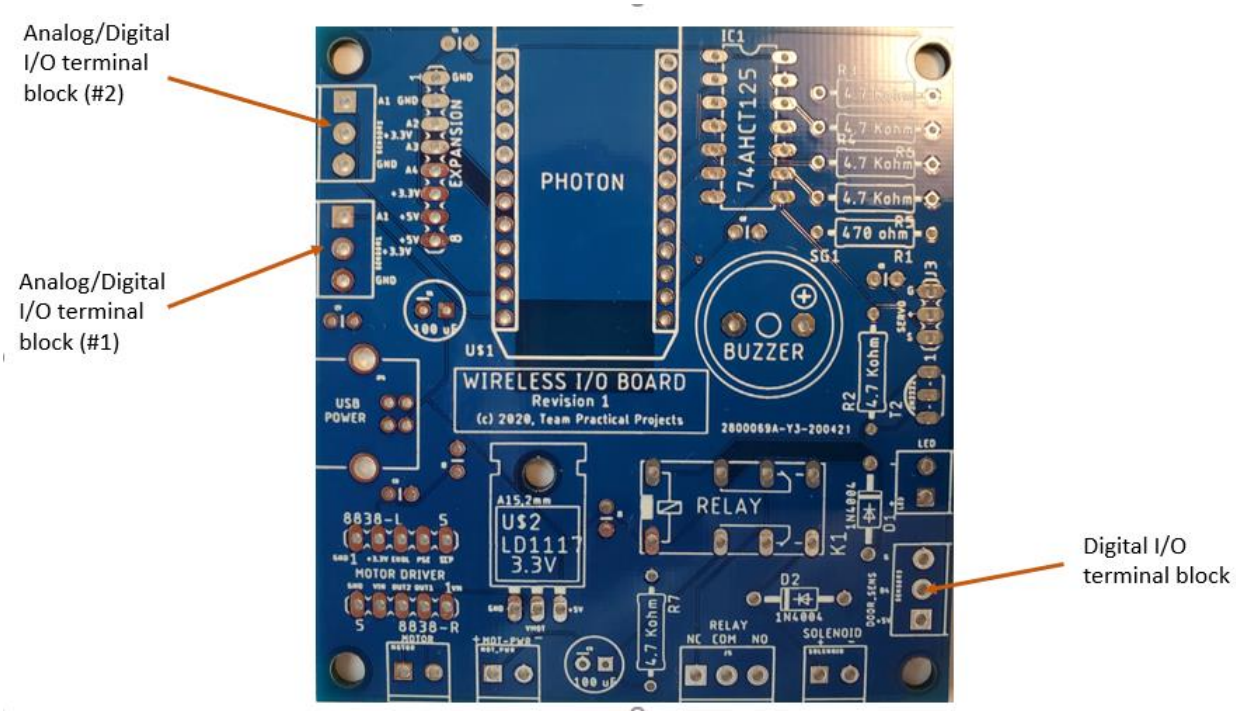


*Figure 2-6. General Purpose I/O.*

## Digital I/O Terminal Block.

This is a 3-position terminal block that provides +5 volts, Ground, and a direct connection to Photon pin D4. When programmed to be a digital input pin, D4 is 5 volt tolerant. It can also be programmed to use an internal (to the Photon) pullup or pulldown resistor. D4 can also be programmed to be a general purpose digital (3.3 volt) output.

## Analog/Digital Terminal Blocks #1 and #2.

These two 3-position terminal blocks each provide +3.3 volt power (from the Photon's internal voltage regulator), Ground, and a direct connection to Photon pin A0 (#1) or A1 (#2). Photon A0 and A1 are general purpose 3.3 volt I/O pins. They can each be programmed for analog input (0 – 3.3 volts), digital input, or digital output. These pins are not 5 volt tolerant and should only connect external signals that are between ground and +3.3 volts.

# 3. ASSEMBLY INSTRUCTIONS AND BEST PRACTICES.

This section provides step by step instructions for assembling the *Wireless I/O board* completely. You may follow these steps leaving out any parts that you do not need for your project.

The assembly steps in this section reflect what we believe to be best practices and techniques for assembling this board. Generally speaking, we recommend soldering in components from the shortest to the tallest. This is because some components need to be taped down to the component side of the board in order to hold them in place when inverting the board for soldering. You may, of course, choose your own means for handing these situations. In any event, only through hole soldering is required (no surface mount components).

We recommend soldering the seven 0.1 uF decoupling capacitors as the first step in assembling the Wireless I/O Board; see figure 3-1.

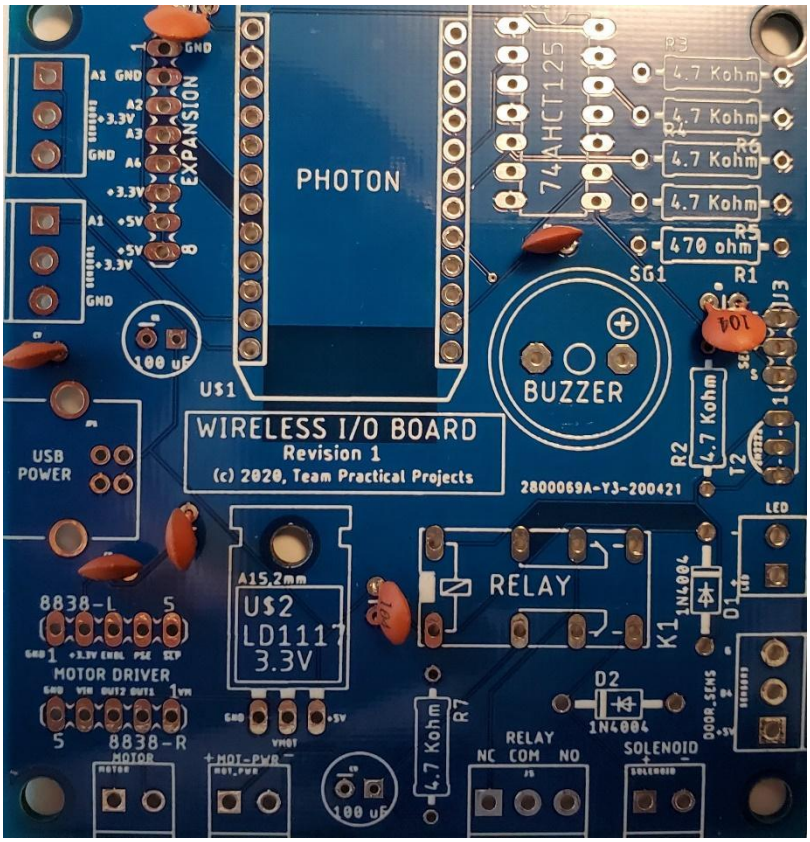


*Figure 3-1. Decoupling Caps.*

Insert the capacitors, bend the leads on the reverse side of the board to hold the parts in place. Then, invert the board and solder the leads,  Clip off the excess leads after soldering.

The next step is to solder the resistors onto the board.  Resistor R1 has a different value from the rest, so we suggest soldering it in now; see figure 3-2.

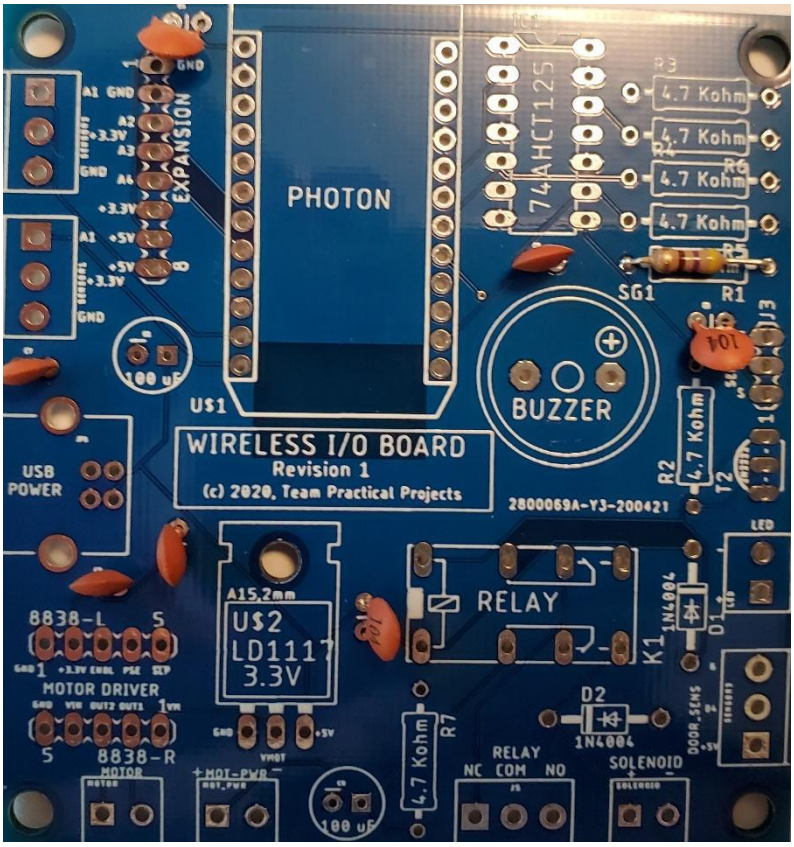


*Figure 3-2.  Resistor R1.*

Insert the resistor onto the board and bend the leads on the reverse side of the board to hold the parts in place.  Then, invert the board and solder the leads,  Clip off the excess leads after soldering.

The remaining resistors (R2 – R7) are all the same value.  Place and solder these resistors now, per figure 3-3, using the same techniques as above.

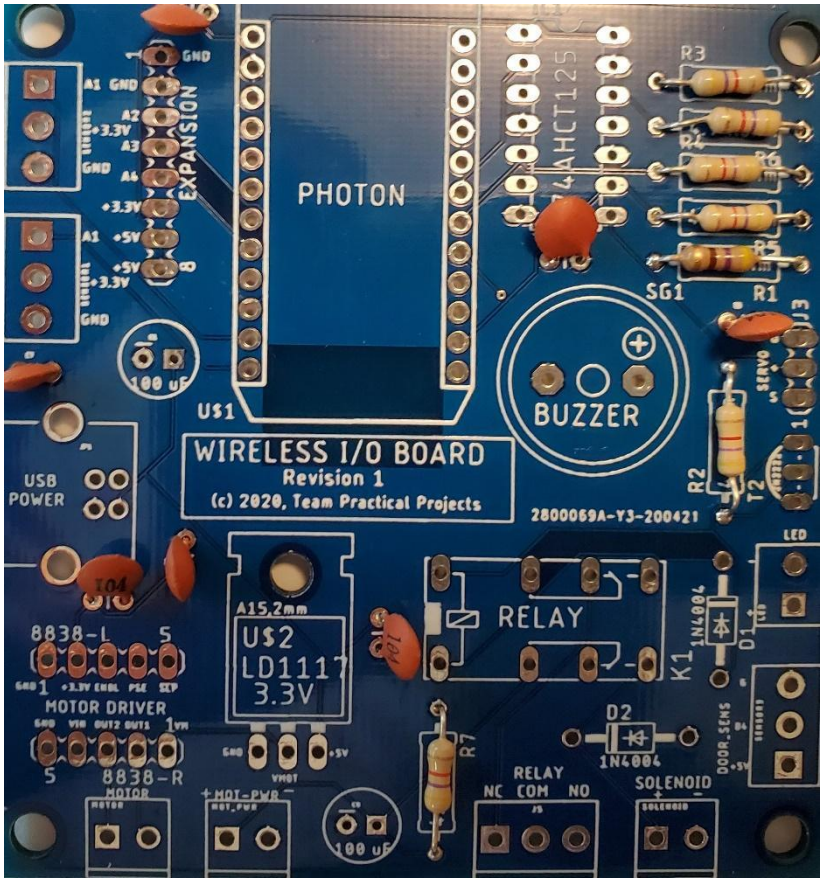


*Figure 3-3. Remaining resistors.*

The next component to add to the board is the 14 pin IC socket. Unlike capacitors and resistors, the IC socket does not have leads that can be bent over on the solder side of the board to hold the part in place while soldering. Our preferred technique is to place the socket on the board and tape it down using electrical tape so that it stays in place when the board is inverted for soldering; see figure 3-4.

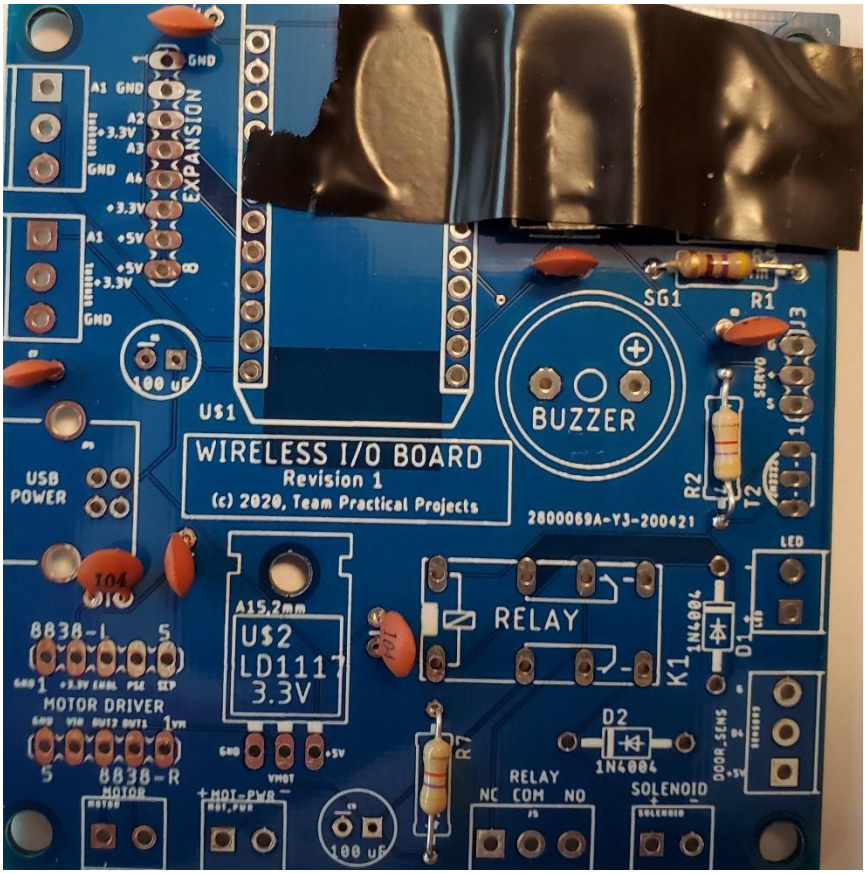


*Figure 3-4. Taping IC Socket.*

After taping the socket in place, double check that the socket is fully inserted onto the board and then invert the board and solder two, diagonally opposed pins first. This will hold the socket in place while soldering the rest of the pins. After soldering the two diagonally opposed pins, double check that the socket remains fully inserted onto the board before soldering the rest of the pins. Check all solder connections and then remove the tape; see figure 3-5.

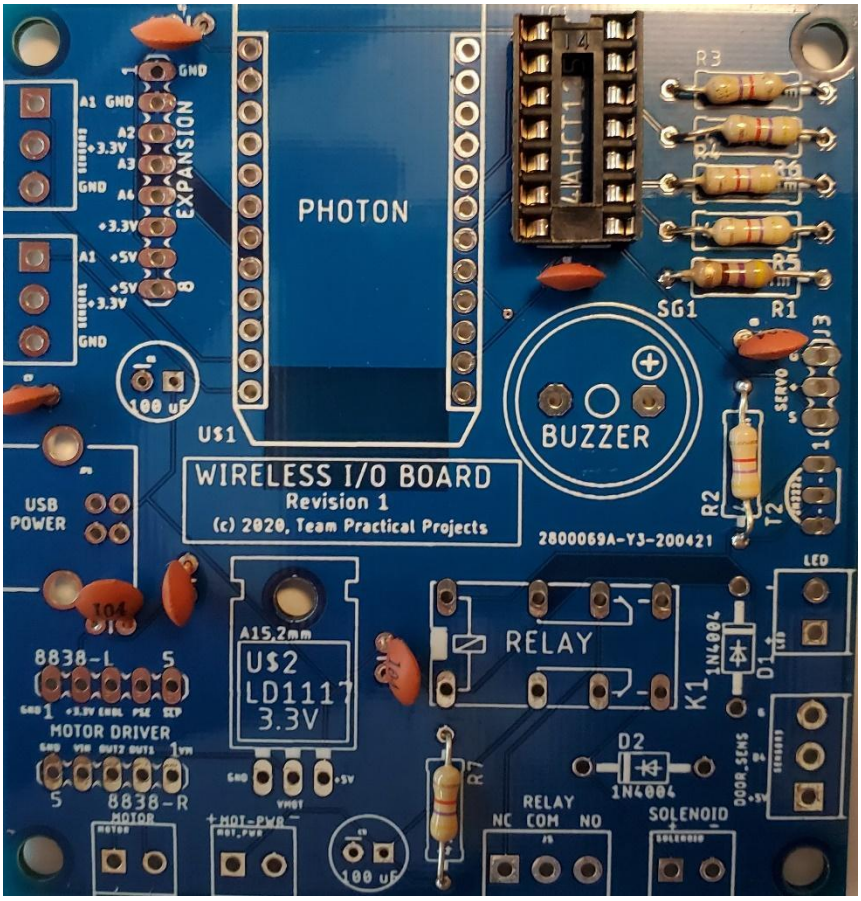


*Figure 3-5. IC Socket Soldered to Board.*

Next, we recommend soldering the buzzer to the board. The buzzer is polarized with the long pin being the positive (+) side. The polarity is also stamped onto the plastic case of the buzzer. Make sure that the buzzer is fully inserted onto the board with the positive pin in the hole with the “+” sign above it. Now, use some electrical tape to hold the buzzer firmly onto the board; see figure 3-6.

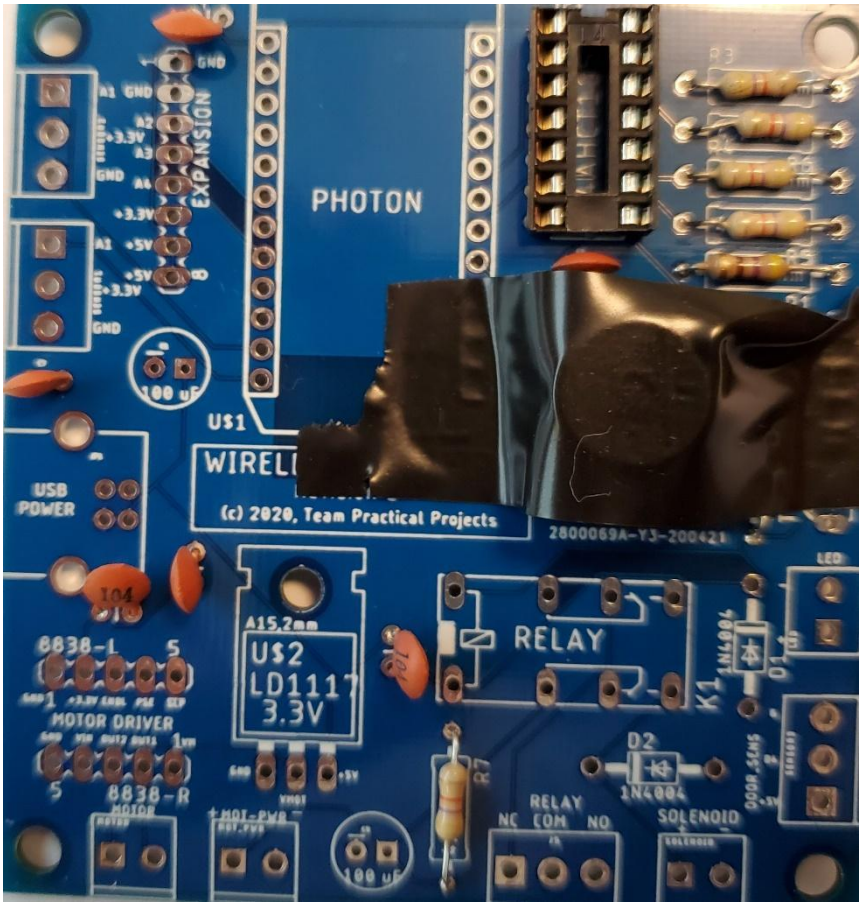


*Figure 3-6. Taping the Buzzer.*

Invert the board; double check that the buzzer is fully inserted onto the board and solder the buzzer pins. The board should look like figure 3-7.

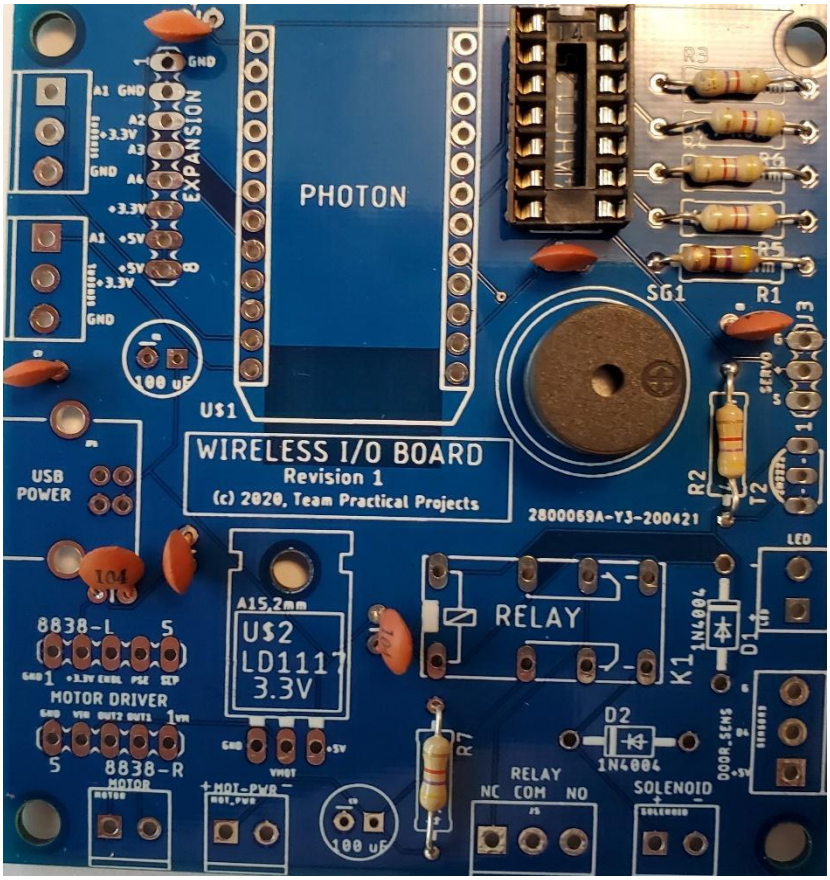


*Figure 3-7. Buzzer Soldered to Board.*

The next recommended step is to solder the 2N2222 transistor onto the board. Insert the transistor onto the board with the flat side facing outward, following the pattern silkscreened on the board. Bend the leads on the opposite side of the board to hold the transistor in place; then invert the board and solder all three transistor leads. Clip off the excess leads after soldering. See figure 3-8.

Not shown in figure 3-8, but recommended at this time, is to insert the two diodes (D1 and D2) onto the board. Insert each diode with the band on the component in the same orientation as indicated on the silkscreen on the board. Double check the orientation. Then bend the diode leads to hold the diodes onto the board. Invert the board and solder the leads. Clip off the excess leads after soldering.

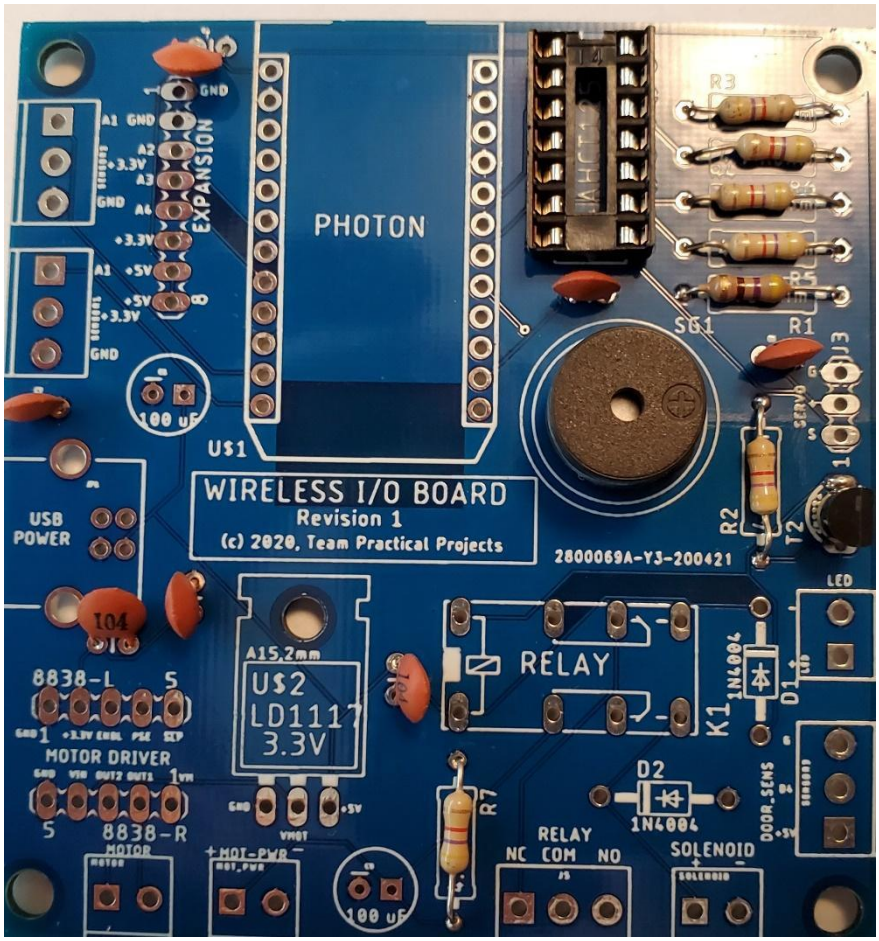


*Figure 3-8. Transistor Soldered to Board.*

We next recommend soldering all of the 2 and 3 position terminal blocks onto the board. Place each terminal block in the position indicated with the wire connection holes facing outside of the board. You will need to use electrical tape to hold each terminal block firmly to the board while soldering the leads. Note that the terminal blocks fit slightly loosely and you should take care to try and align each terminal block so that they look neat and professional after soldering. This takes some care when taping each block to the board. A mis-aligned terminal board will still work well but it won't look neat and professional. Some of the terminal blocks in figure 3-9 look neat and professional and others are slightly askew, but they all work.

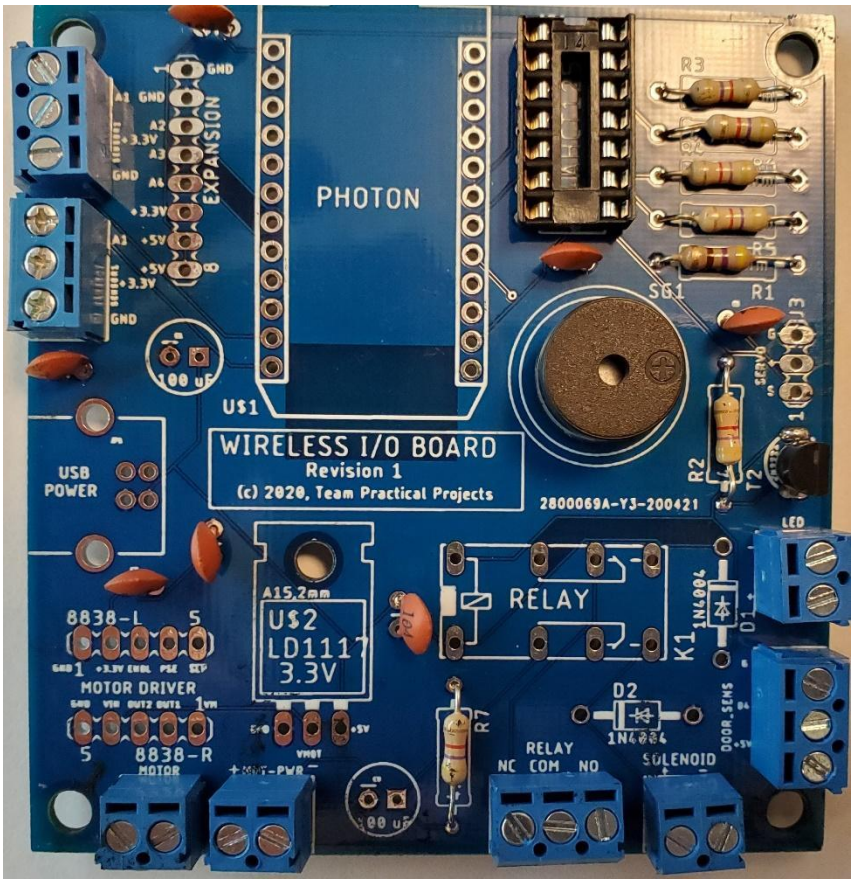


*Figure 3-9. Terminal Blocks Soldered to Board.*

The next suggested step is to solder the 3-pin male pin header for the servo to the board. The male pin headers come in long strips. Break off a 3 pin section using long nose pliers. Then insert the short pins through the board and use electrical tape to hold the pin header in place. Once again, try to align the pin header to be absolutely straight and vertical while taping. It will work regardless, but it will look much neater and professional if you take the time to do this. After double checking that the tape is holding the pin header fully onto the board, and that it is straight and vertical, invert the board and solder the pins. See figure 3-10.

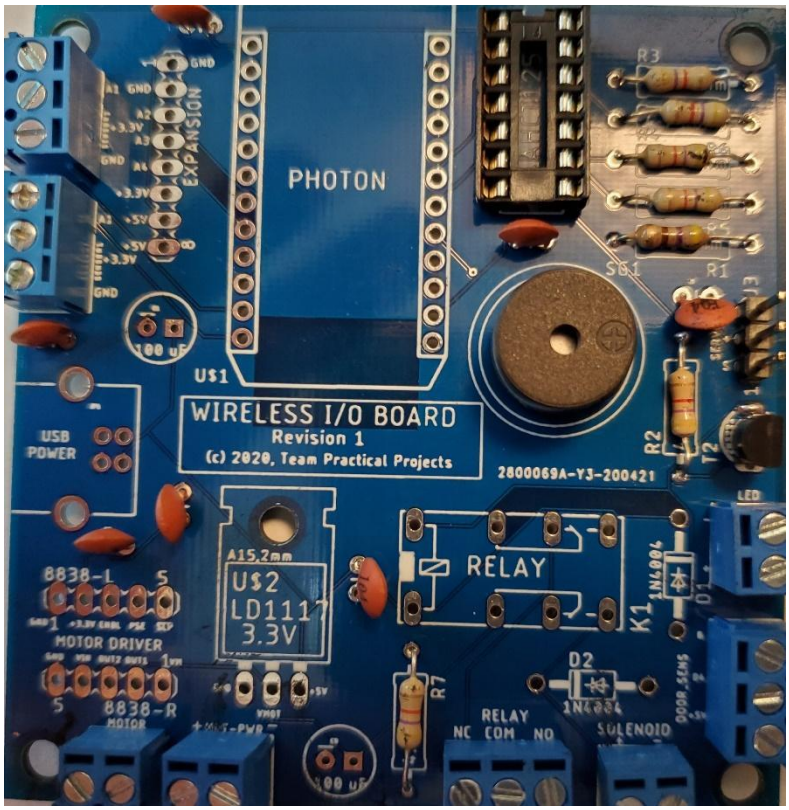


*Figure 3-10. Male Pin Header Soldered to Board.*

Insert the USB connector onto the board. The two large leads on the side will clip it to the board, so that it may not need to be taped down for soldering. It is the 4 small pins that count here. Invert the board and solder these 4 pins carefully – they are very close together. You can also solder the large clip leads on the side of the connector. These aren't necessary electrically but soldering them will help keep the connector securely affixed to the board. Refer to figure 3-11.

Place the two 100 uF electrolytic capacitors onto the board and bend the leads to hold each one in place. Note that these devices are polarized. There is a silver stripe down the NEGATIVE side of each capacitor. Make sure that the lead by this silver stripe is in the round hold marked with a "-" and that the other lead is through the square hole. Bend the leads to hold the components onto the board and solder. Clip off the excess leads after soldering. See figure 3-11.

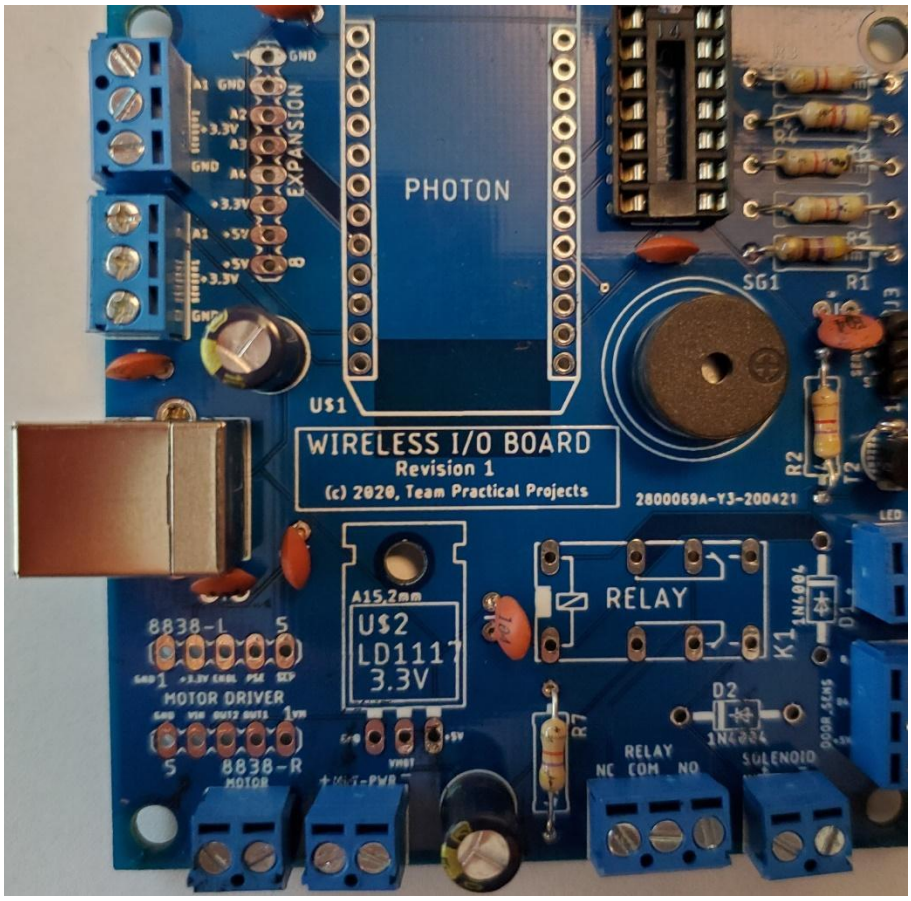


*Figure 3-11. USB Connector Soldered to Board.*

In figure 3-12 below, we have chosen to use a 3-pin female header as a socket for the LD1117 voltage regulator. It is not necessary to use a socket and you can solder the device directly to the board if you wish. However the LD1117 device is attached to the board, the plastic side should face up (metal side down to the board, when the device's pins are bent 90 degrees). In other words, after the device is mounted to the board, it should cover the silkscreen outline on the board with the all-metal side down and plastic side facing up. If a female header is used as in figure 3-12, use electrical tape to hold the header onto the board for soldering, as you have done in previous steps. Bend the LD1117 device's leads over 90 degrees and plug it into this socket (or skip the socket and solder it directly to the board).

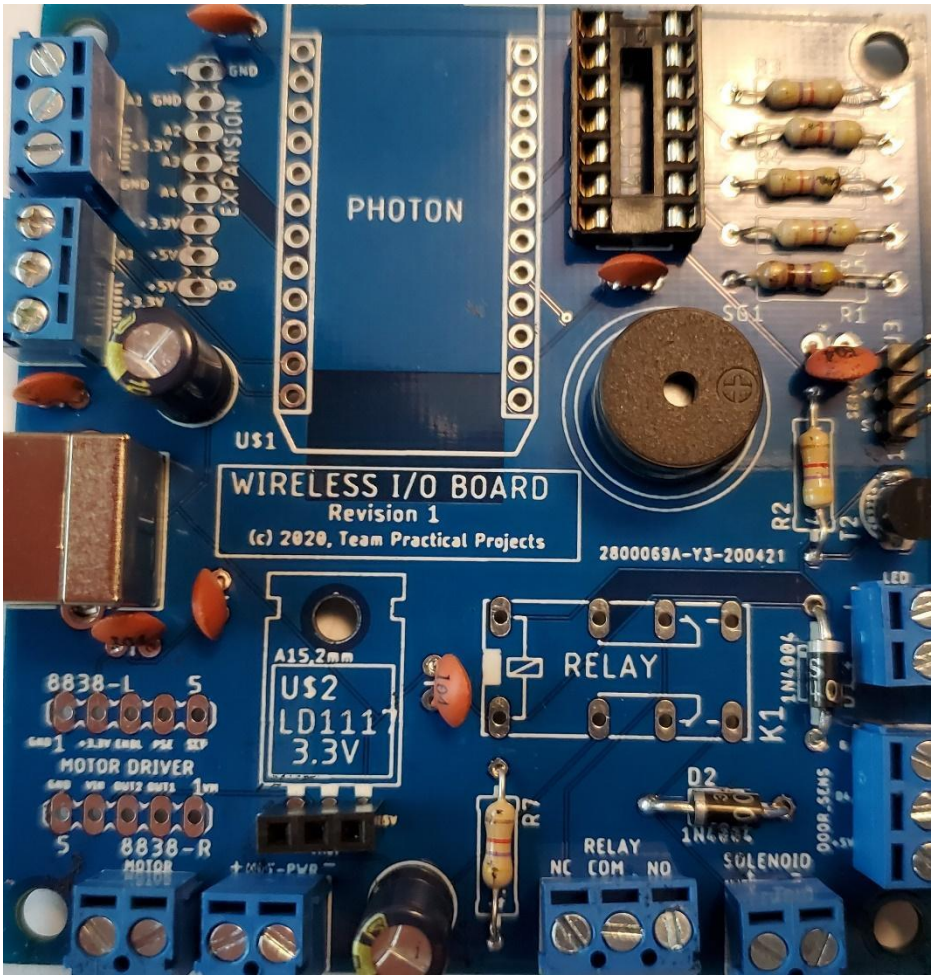


*Figure 3-12. 3 Pin Female Header for Voltage Regulator.*

The Pololu DRV8838 small motor controller module comes with straight and angled male headers. The straight headers should be soldered to the module. The recommended way to do this is to take a solderless breadboard and insert the longer leads of each straight header onto the breadboard on either side of center. Then place the controller module SILKSCREEN SIDE UP on top of the short leads of the headers. Solder the header to these pins. See figure 3-13.

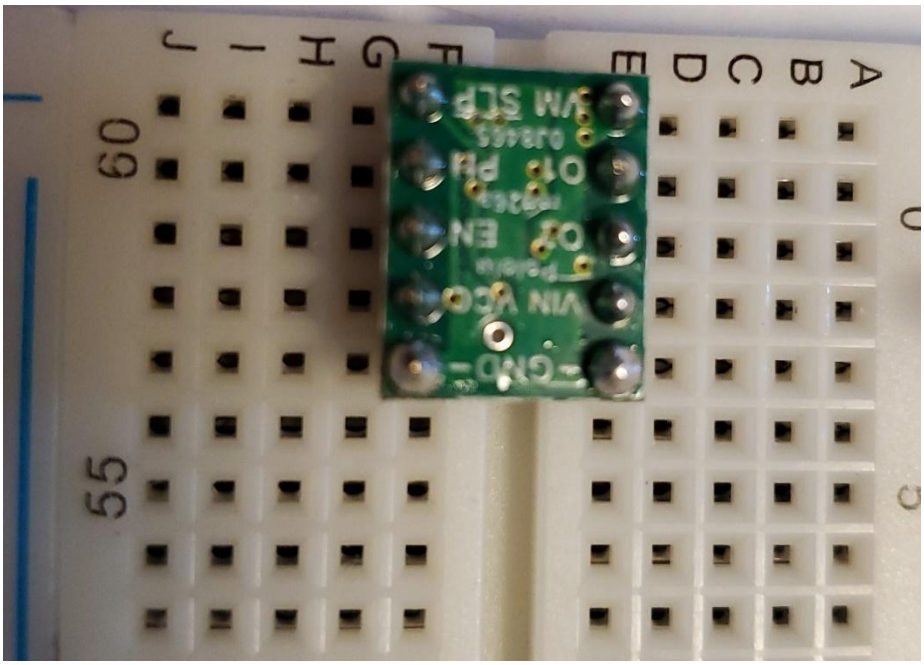


*Figure 3-13. Soldering Header Pins to Motor Controller.*

Remove the module from the solderless breadboard. Now take two 5-pin female headers and insert them onto the long pins of the module, as shown in figure 3-14. These female headers will form a socket for the motor controller module.

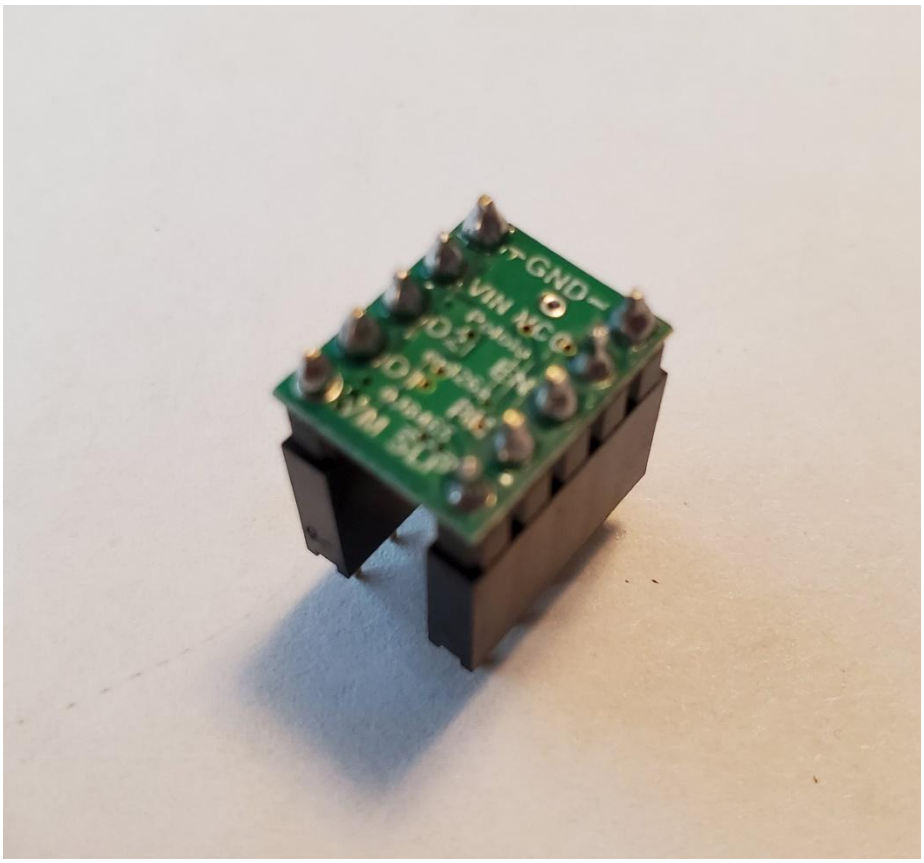


*Figure 3-14. Preparing 5 Pin Female Headers for Soldering.*

Next, place the assembly of figure 3-14 onto the motor controller socket pin positions on the *Wireless I/O Board*. The module orientation does not matter at this point as the module can be removed and rotated later, if needed. Use electrical tape to firmly hold the module onto the board; see figure 3-15. As always, double check that the socket pins are fully inserted onto the board.

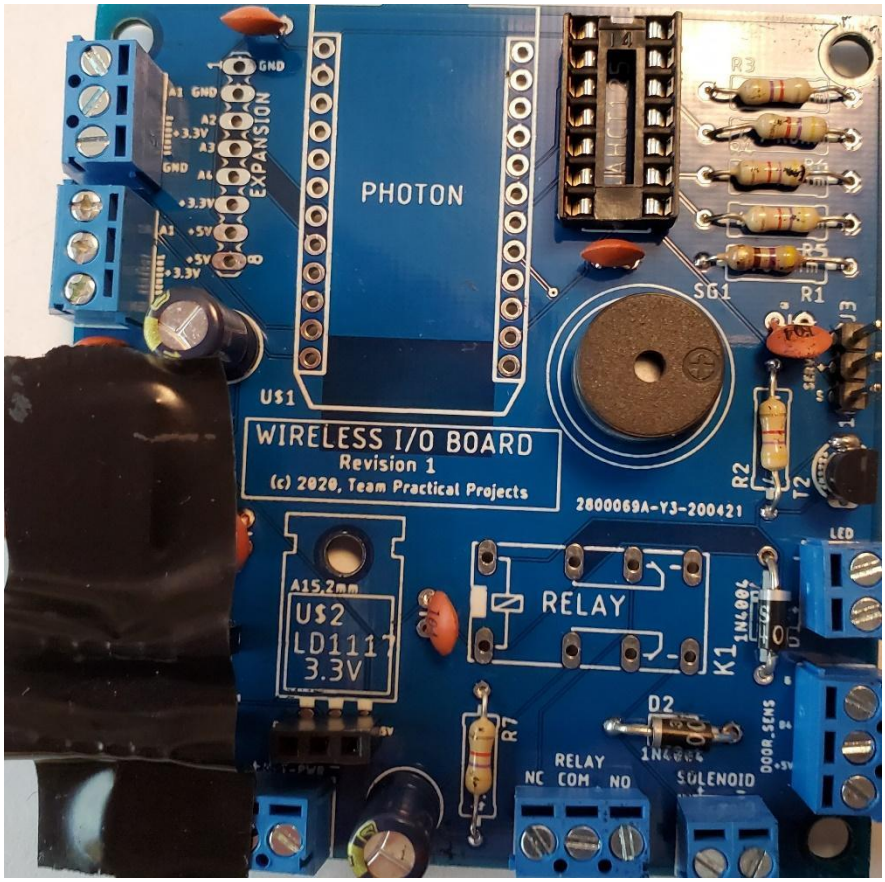


*Figure 3-15. Taping Motor Controller to Board.*

Invert the board and solder the four corner pins (two on each side) to affix the headers into place. Remove the tape and the DRV8838 module (to protect it from heat damage). Then solder all remaining header pins and double check the solder joints. See figure 3-16.

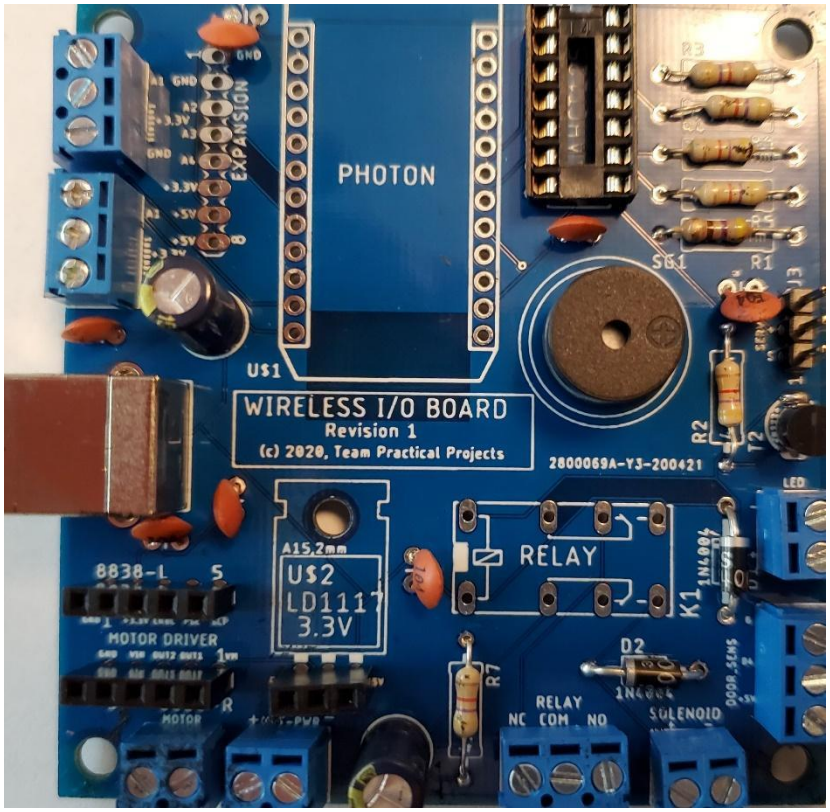


*Figure 3-16. Motor Controller Female Headers Soldered to Board.*

Insert the relay onto the board. The relay pins are polarized and the relay can only be inserted one way. Tape the relay firmly down on the board using electrical tape and double check that it is full inserted on the board. Invert the board and solder all relay pins.

The final step is to mount the Photon socket to the board. The Photon socket is made from two 12-pin female headers. A Photon or an old Spark Core will be used to hold these two headers in proper alignment for soldering. Take an old Photon or Core (if you have one; if not, use the Photon for this project), invert it and plug two 12 pin female headers fully onto the Photon/Core's male header pins. See figure 3-17 for details.

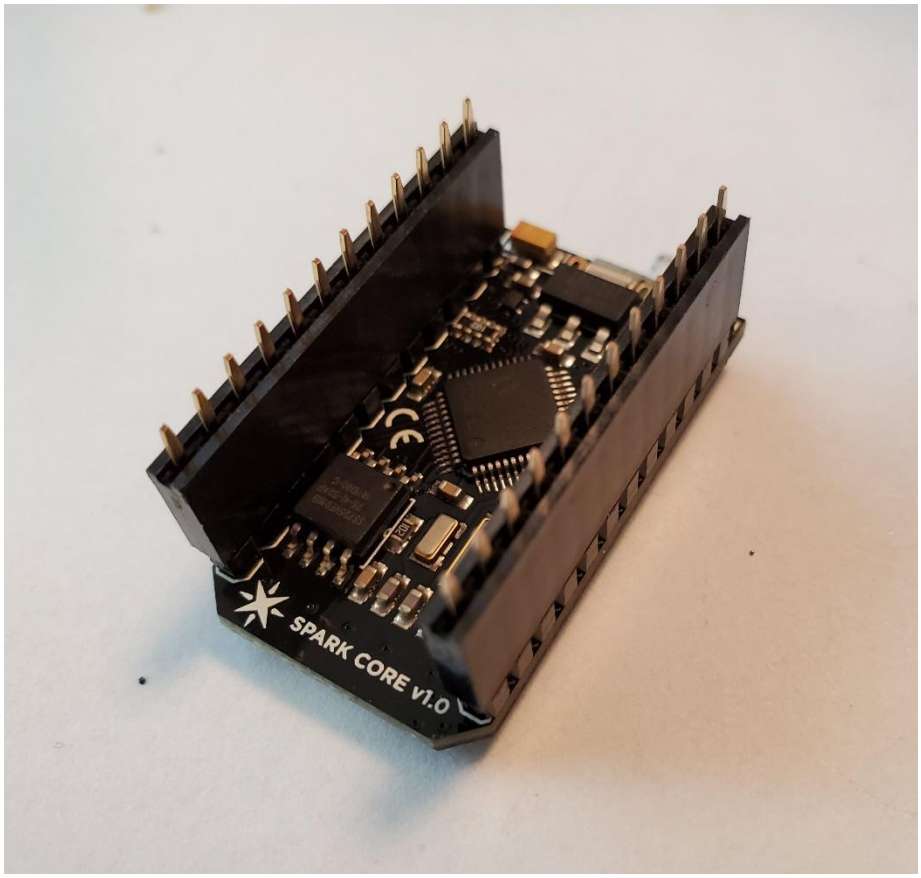


*Figure 3-17. Preparing Photon Female Header Connectors.*

Take this assembly and plug if fully into the board. The Photon/Core polarity does not matter at this point as it can be replaced later. Use electrical tape to firmly hold the Photon/Core onto the board and double check that the short connector pins are fully inserted into the board. Invert the board and solder the two end pins and one middle pin on each female header. These will hold the headers onto the board. You may now CAREFULLY remove the tape and unplug the Photon/Core from the socket. This will protect it from heat damage while soldering the remaining connector pins. Now, solder the remaining socket pins to the board.

The board is fully assembled by inserting the socketed components; see figure 3-18:

- Level Shifter IC: The 74AHCT125 is inserted into the 14 pin IC socket with the notch on the chip facing the top of the board. If the chip does not have a notch, then there is a dot by pin 1 and this dot should face the top of the board.

- Photon: The micro USB connector on the Photon should face the top of the board.

- DRV8838 Motor Controller: The pins that say – GND – should face the outside of the board.

- LD1117 Voltage regulator: The plastic side should face the outside of the board, or face upwards when the part is bent over 90 degrees.

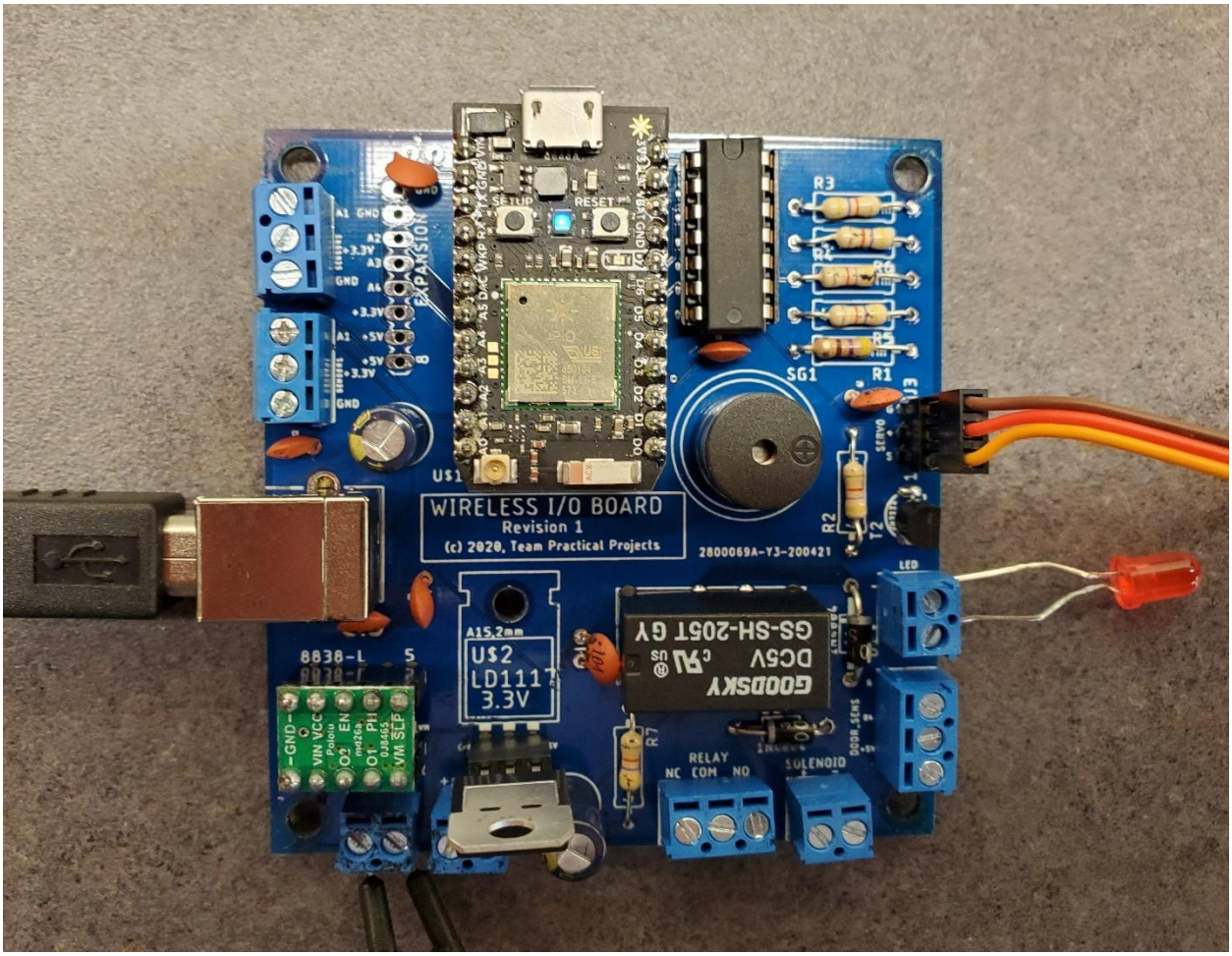


*Figure 3-18. Completed Board.*

Instructions for powering up and testing your completed *Wireless I/O Board* are contained in the document “Wireless IO Board User Manual” that is also in this repository.