Wireless I/O Board
User Manual

By: Team practical projects, Jim Schrempp and Bob Glicksman; v1, 5/26/2020

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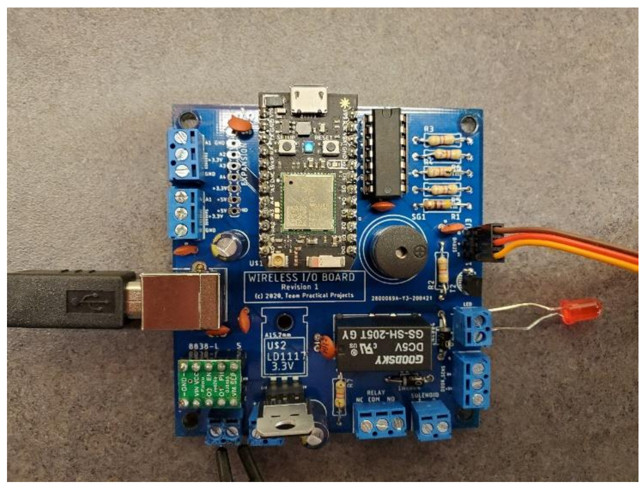
https://github.com/TeamPracticalProjects/Wireless_IO_Board/blob/master/Terms_of_Use_License_and_Disclaimer.pdf



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1. OVERVIEW.

The *Wireless I/O Board* provides a variety of Internet-accessible controls for actuators and sensors. The Board is based upon the Particle Photon[1]: a low cost, 32 bit microcontroller module with built-in WiFi capability. The *Wireless I/O Board* provides the following capabilities that are accessible through firmware on the Photon:

- Control of a small motor
- Control of an on-board relay
- Control of an external solenoid, via the relay
- Control of a hobby servo
- Control of an on-board buzzer
- Control of an external LED
- A 5 volt tolerant general purpose digital I/O capability
- Two 3.3 volt analog inputs; alternatively, general purpose digital I/Os

Section 2 of this document contains detailed information about each of these capabilities. Section 3 of this document describes firmware that can be flashed to the Photon to test out some of the functional capabilities of this Board.

It is not necessary to assemble all of the components supported by the *Wireless I/O Board.* Only those components needed for any specific project need to be purchased and soldered onto the Board. The document “Wireless_IO_Board_Build_Instructions” that is also in this repository provides detailed information about which parts are needed to support which functions, as well as recommended procedures for assembling the Board.

2. FUNCTIONS AND SPECIFICATIONS.

2.1. Wireless I/O Board Physical and Power Input.

Figure 2-1 depicts a fully assembled *Wireless I/O Board* and calls out the major components that are required for any application of the Board.

[1] https://docs.particle.io/datasheets/wi-fi/photon-datasheet/

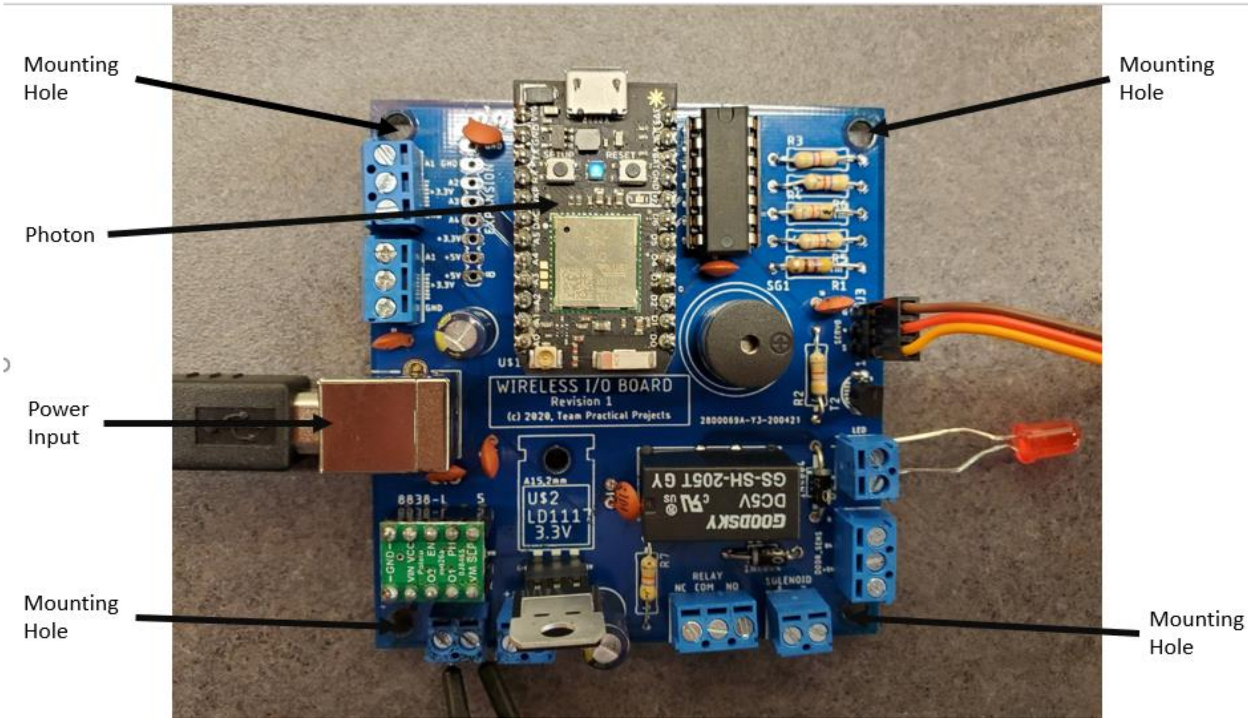

Figure 2-1. Wireless I/O Board Overview.

The Particle Photon module and the USB type-B power connector are always required.

2.1.1. Board Size and Mounting.

The *Wireless I/O Board* is 3.00 inches high and 2.85 inches wide. Four mounting holes are provided on the Board. Each hole is 0.1495 inches in diameter and accommodates #6 hardware.

2.1.2. Board Power.

The *Wireless I/O Board* is powered via a USB Type-B connector. Alternatively, the Board may be powered via the micro-USB on-board the Photon. The latter is not recommended, however, because there is a diode drop (approximately 0.3 volts) between the Photon's 5 volt input voltage and the on-board 5 volt power. It is safe to power the board from a USB 5 volt source using the Type-B connector while connecting the Photon to a computer using the Photon's on-board micro USB connector. Note that the Photon firmware is flashed over WiFi, so the only use of the Photon's micro-USB connector would be for debugging.

5 volt power to the Board should be between 5.25 volts and 4.75 volts. The Photon itself draws approximately 100 ma from the 5 volt power; however, additional components on the board can raise the power requirement up to 2 amps. The actual power supply requirement will depend upon the components loaded onto the Board and the external loads connected to it.

2.2. Small Motor Controller.

Figure 2-2 shows the major components and connections to use to run a small motor from the *Wireless I/O Board.*

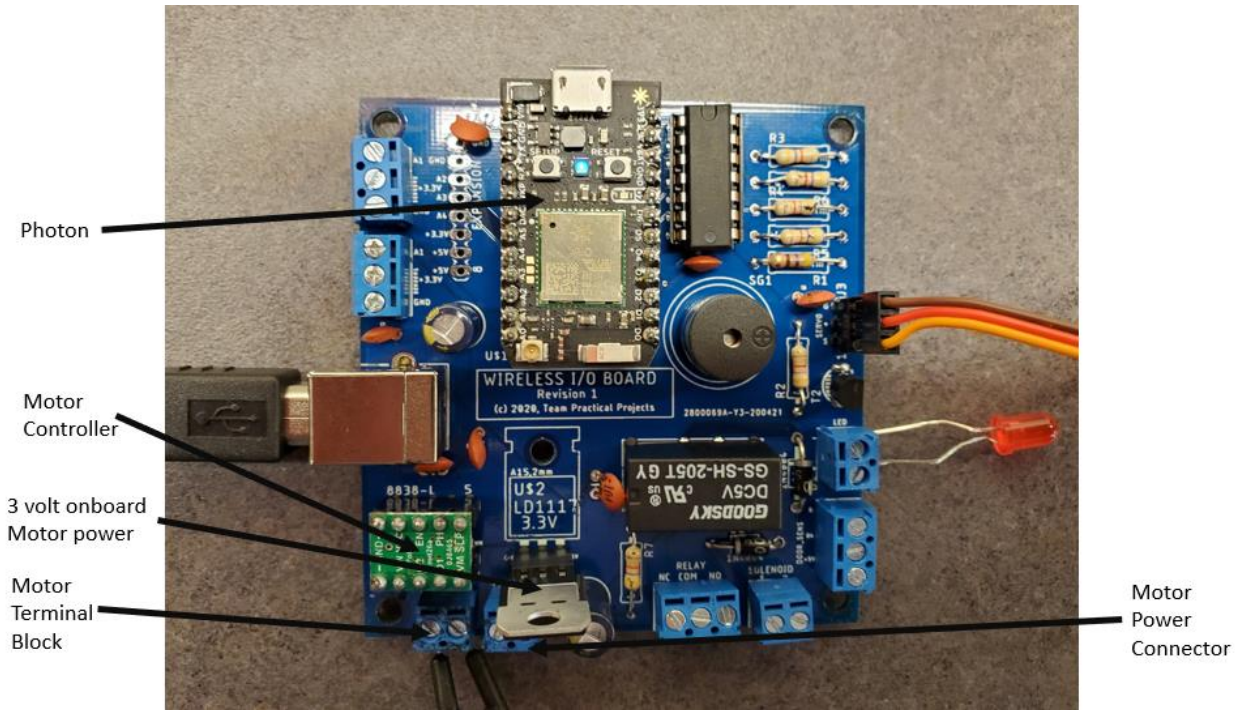

Figure 2-2. Small Motor Control.

2.2.1. Functional Description.

A Pololu DRV8838[2] small motor driver module is used to control speed and direction of a small brushed DC motor. The DRV8838 contains an H-bridge circuit for independent control of motor speed and motor direction.

Photon pin D2 controls motor rotation direction, while Photon pin D3 controls the motor run (on-off). PWM (analogWrite()) can be used to control the motor's speed via pin D3.

An on-board LD1117-33[3] low dropout linear voltage regulator can be used to provide 3.3 volt power to an attached motor. Alternatively, this component can be left off of the Board and motor power can be supplied to the Board via the Motor Power terminal block.

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[2] https://www.pololu.com/product/2990

[3] https://www.jameco.com/shop/ProductDisplay?catalogId=10001&langId=-1&storeId=10001&productId=242114

2.2.2. Physical Connections.

A 2-terminal connector provides connection to an external DC motor's leads; see figure 2-2. If the on-board 3.3 volt motor supply is used, then no other connections are needed. If the on-board motor supply voltage regulator is left off of the board, then a second 2-position terminal block is used to bring external motor power on to the Board; see figure 2-2. If the internal LD1117-33 voltage regulator is included on the board, this second screw terminal may be used as a motor power output from the board (for test purposes or to power some other external device).

The motor power is completely separate from the Photon's on-board 3.3 volt regulated logic power.

2.2.3. Specifications.

The DRV8838 motor driver can control brushed DC motors with up to 11 volts power and up to 1 amp of motor power current. The on-board LD1117-33 voltage regulator supplies regulated 3.3 volt power for a motor at up to 800 ma.

2.2.4. Applications.

The *Wireless I/O Board* small motor controller function may be used to operate any small DC motor. We have used it to remotely unlock a Tokatuker RFID cabinet lock[4]. The latter contains a small 3 volt DC motor that rotates 180 degrees clockwise to unlock the cabinet and 180 degrees counterclockwise to re-engage the lock. We removed the electronics and batteries from this lock and connected the locking motor leads directly to the motor control screw terminal of the Board (using the on-board voltage regulator for motor power). We found that pulsing Photon pin D3 for approximately 30 ms reliably moved the motor-lock the required 180 degrees. The test firmware included with this project (described on section 3 of this document) contains a function that unlocks this device for 2 seconds and then locks it again. This function can be called from the Particle Console for testing purposes.

2.3. Relay / Solenoid Control.

Figure 2-3 shows the major components and connections to use to activate the on-board relay and to control an external solenoid or other external load.

[4] https://www.amazon.com/Tokatuker-Electronic-Cabinet-Hidden-Drawer/dp/B075QF1VPR

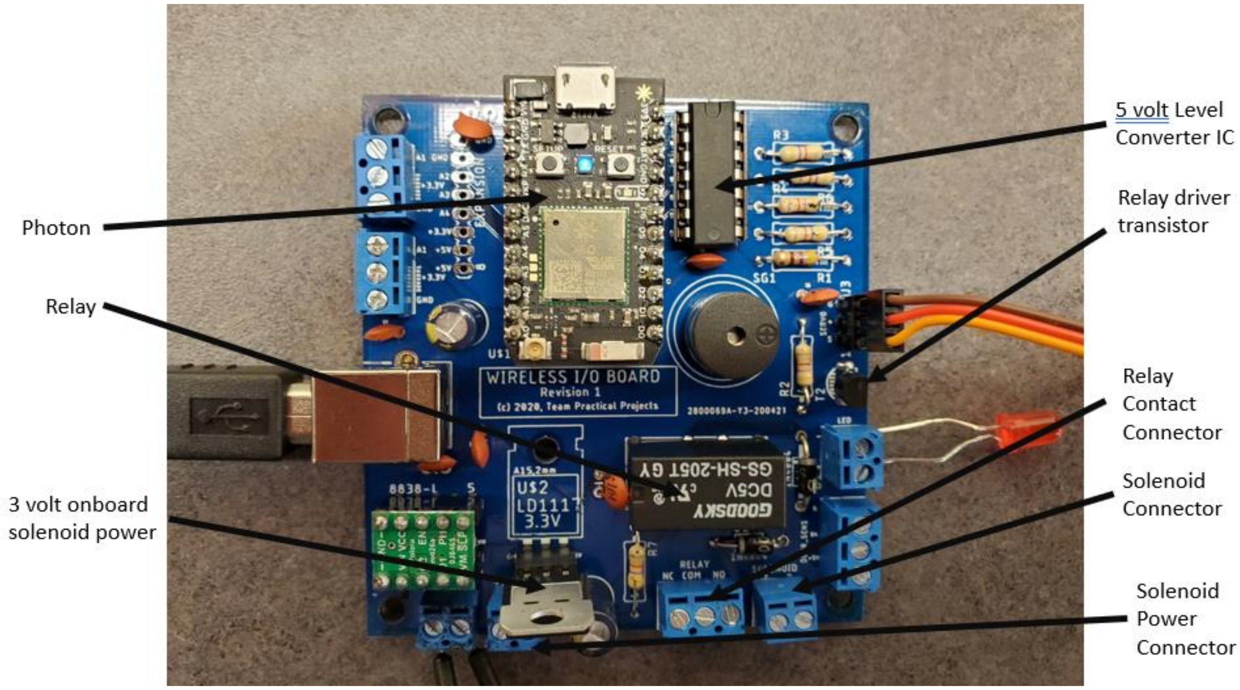

Figure 2-3. Relay/Solenoid Control.

2.3.1. Functional Description.

The *Wireless I/O Board* accommodates a small, double pole double throw (DPDT) relay. The relay is activated by setting Photon pin D0 HIGH and deactivated by setting D0 LOW. The Board contains all circuitry necessary to drive this relay, including a level converter IC (with associated pulldown resistors), a current amplifying transistor and base resistor, and a flyback diode for the relay coil.

One pole of the relay is brought out to a 3 position terminal block. The common (COM), normally open (NO) and normally closed (NC) contacts of the relay are available on this terminal block.

The second pole of the relay supplies motor power and corresponding ground to a 2 position terminal block. The motor power can be 3.3 volt power from the LD1117 voltage regulator (also used for motor driver power; see section 2.2 above). Alternatively, the LD1117 voltage regulator can be left off of the board and external power can be supplied via the motor power terminal block; see section 2.2 above. A flyback protection diode is also included between switched power and ground on the 2 position terminal block so that it can be used to power a solenoid or other inductive load. Of course, resistive loads can be connected to this terminal block as well.

2.3.2. Physical Connections.

Figure 2-3 shows the two terminal block connectors associated with the on board relay. The 3 position "Relay Contact Connector" provides direct connection to COM, NO and NC contacts of one pole of the relay. The 2 position "Solenoid Connector" provides relay-switched power to an external load. The switched power polarity is marked above the connector.

The 2 position terminal block marked "Motor Power Connector" (in figure 2-2) can be used to supply external power for the "Solenoid Connector" in the event that the internal 3.3 volt motor power is not used.

2.3.3. Specifications.

The onboard relay specifications can be found at:
https://www.jameco.com/Jameco/Products/ProdDS/139977.pdf

Relay Contacts: The relay contacts are rated at: up to 120 VAC at 1 amp maximum, or up to 24 VDC at 2 amp maximum. Note that extreme care must be undertaken when voltages above 24 volts are brought on to the *Wireless I/O Board.*

Solenoid Connector Switched Power: The internal LD1117 supplies regulated 3.3 volt DC power at up to 800 ma current draw. If the LD1117 is left off of the Board, external power supplied through the "Motor Power Connector" can be up to 24 VDC at up to 2 ampere draw. *Note however, that if this external power is also used to power a small motor (section 2.2, above), then external power is limited to 11 VDC*. Only DC power may be used for this connection owing to the presence of the flyback diode.

2.3.4. Applications.

The general purpose relay contacts may be used to control a wide variety of AC and DC powered devices. These include lamps, pumps, motors and industrial relays (contactors) among many other applications. The provision of general purpose mechanical contacts is also useful for remotely controlling switched devices (e.g. garage door opener remote control) by connecting the relay NO/COM contacts across any mechanical switch.

The switched power terminals are useful for driving external DC loads, both resistive and inductive. Inductive loads include DC solenoids that are found in many types of electromechanical air and water valves and in linear actuators. Small DC motors (up to 24 volts) may be powered from these contacts; however, neither motor direction nor motor speed can be controlled this way (see section 2.2, above, for motor control and includes speed and direction).

2.4. Servo Controller.

The *Wireless I/O Board* can control a standard, 5 volt hobby servo. Figure 2-4 shows the major components associated with this capability.

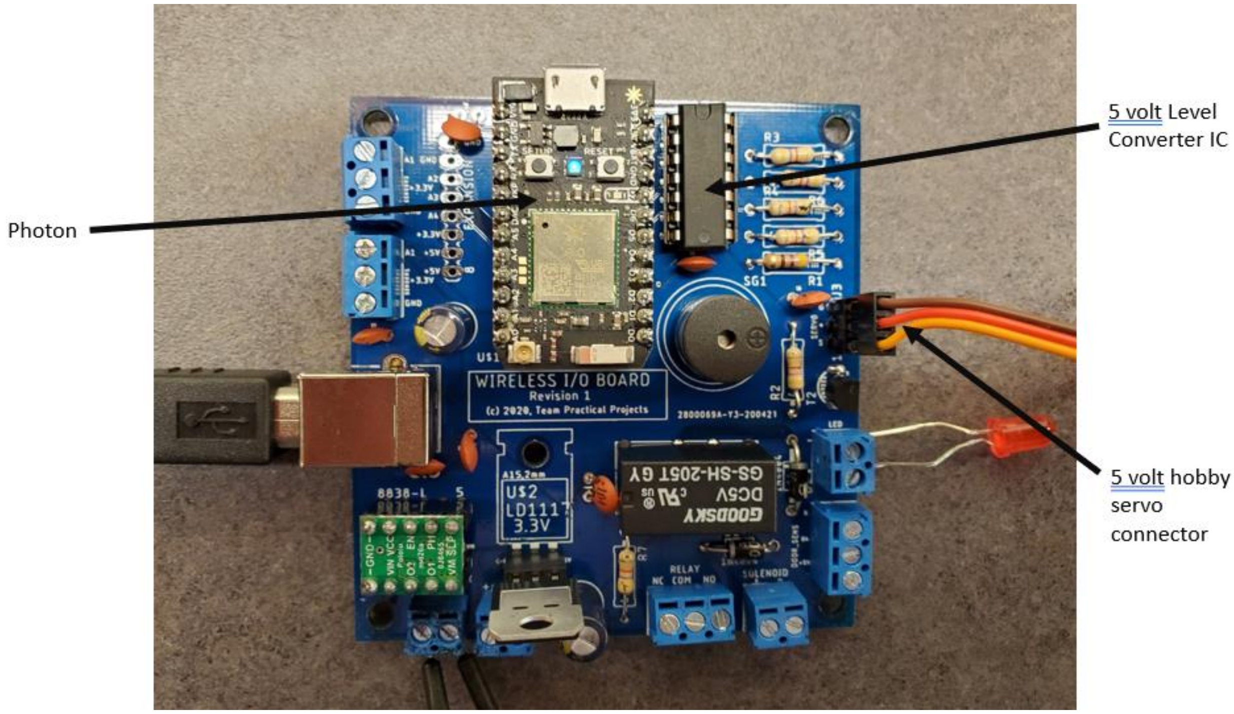

Figure 2-4. Hobby Servo Connection.

2.4.1. Functional Description.

A 74AHCT125 level shifter IC (and associated pulldown resistors) is used to provide a 5 volt output from Photon pin D1. The Particle *Servo Library* may be used to control servo position (or speed, for continuous rotation servos). A male pin header is provided with standard pinouts for all hobby servos. This connector may also be used as a general purpose, 5 volt digital output.

2.4.2. Physical Connections.

A 3 pin male header is provided with the following pinout:

- Pin 1: servo control signal
- Pin 2: 5 volt (Vcc) power
- Pin 3: Ground

This pinout is compatible with the female connector on standard hobby servos.

2.4.3. Specifications.

The Board can drive standard hobby servos. The 5 volt power is the external Board power supplied via the Type-B USB connector. Ground is the Board digital ground. The servo control signal is 5 volts at a maximum of 8 ma.

2.4.4. Applications.

Any general purpose hobby servo may be controlled using the *Wireless I/O Board.* Such servos are used in a wide variety of applications. Closed loop servos provide shaft position control from 0 to 180 degrees. Open loop ("continuous rotation") servos are inexpensive gearmotors whose speed and direction are controlled via the servo signal. All such hobby servos use a common signaling protocol. The Particle *Servo Library* provides simple and convenient firmware control of these types of servos.

2.5. Buzzer and External LED Control.

The *Wireless I/O Board* contains an on-board piezo buzzer that can be used as an audible alert or audible status indicator. The Board also provides a direct connection to an external LED that can be used as a visual alert or indicator. Figure 2-5 shows the components associated with these items.

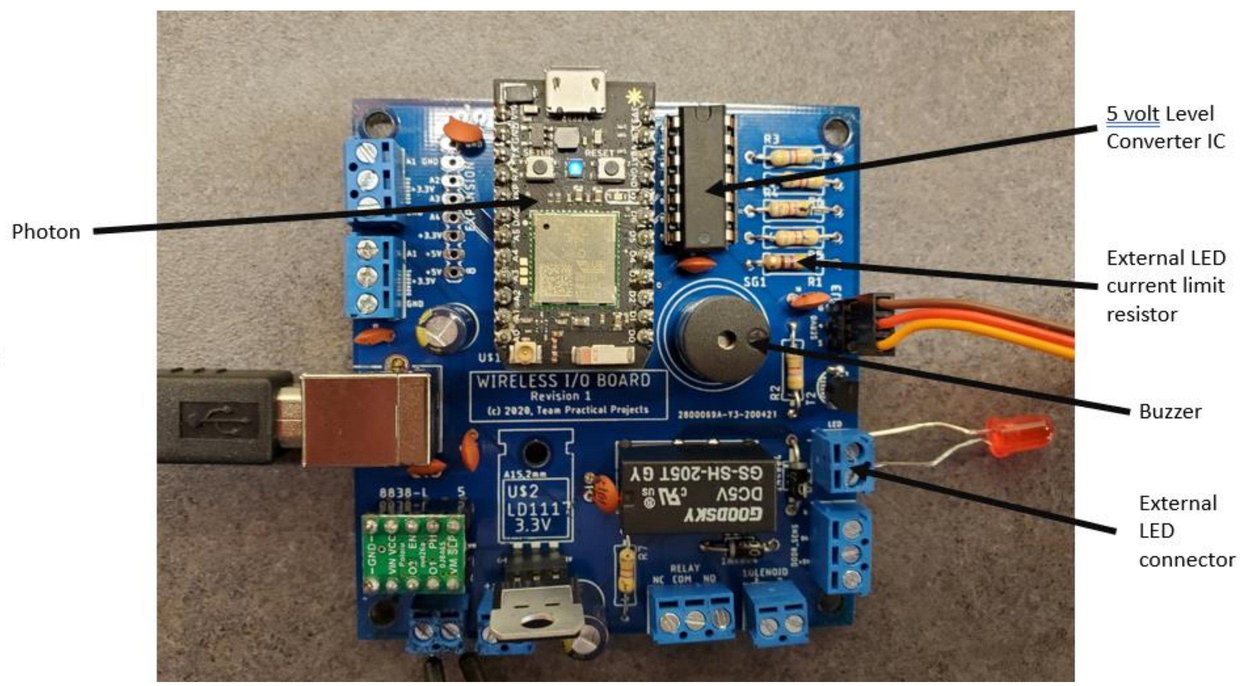

Figure 2-5. Buzzer and External LED.

2.5.1. Functional Description.

Many projects require audible and/or visual indicators. To this end, the *Wireless I/O Board* supports an on-board piezo buzzer and a connector for an external LED. Photon pin D6 turns the buzzer on when HIGH and off when LOW. Photon pin D5 lights an external LED when HIGH and turns the LED off when LOW.

The LED and buzzer are provided with 5 volt signaling via an on-board level converter IC (and associated pulldown resistors). An on-board 470 ohm resistor limits the LED current to approximately 6.5 ma, which is bright enough for most applications. The resistor value may be changed, of course, but the level converter IC can supply a maximum of 8 ma. The LED current limiting resistor can be replaced by a solid wire providing a full 5 volt logic signal on the LED connector. Once again, a maximum of 8 ma can be provided to any load connected to this connector.

2.5.2. Physical Connections.

The buzzer is mounted on the *Wireless I/O Board* and there are no external connections to it. A 2 position terminal block supplies current limited output to an external LED. The LED is wired to this connector as shown in figure 2-5.

2.5.3. Specifications.

The buzzer emits a loud, 2 KHz tone when energized.

The LED is supplied with 5 volt power through a 470 ohm current limiting resistor. The resistor limits the LED current to approximately 6.5 ma. The maximum current that can be provided from this connection is 8 ma.

2.5.4. Applications.

The on-board buzzer can be used to provide a steady alert tone, as needed. Pulsing the buzzer in various ways can produce a “happy” acceptance sound, an “angry” rejection sound and other similar effects.

The external LED connector is intended for an LED that is mounted on a panel or case. The LED state can be visible even when the *Wireless I/O Board* is housed inside of a chassis or other enclosure. In addition to on and off, the LED can be pulsed to provide a variety of effects.

Using a solid wire in lieu of the current limiting resistor allows the external LED connector to be used for a general purpose 5 volt logic output.

2.6. General Purpose Digital and Analog I/O.

The *Wireless I/O Board* provides three, 3-position terminal blocks for general purpose I/O; see figure 2-6.

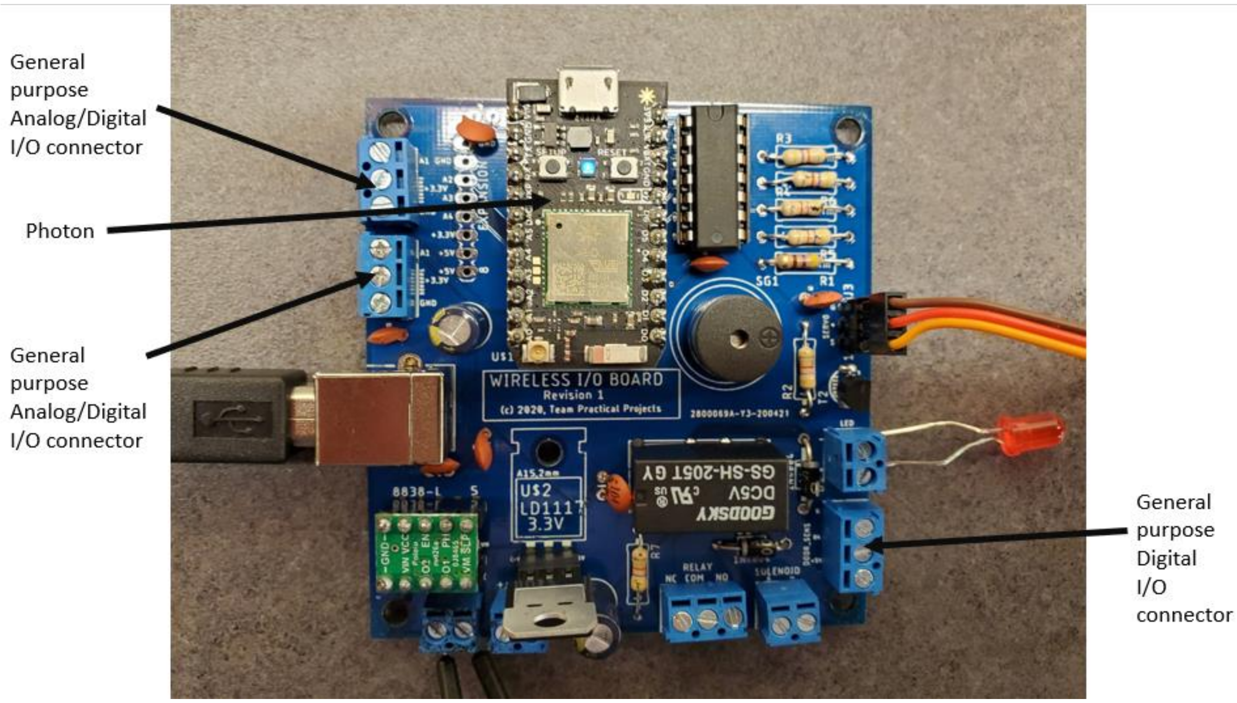

Figure 2-6. General Purpose I/O.

2.6.1. Functional Description.

See figure 2-6. A 3-position terminal block shown at the lower right hand side of the figure connects directly to Photon pin D4 on its middle terminal. The upper terminal connects to the Board 5-volt logic power and the lower terminal connects to ground. The intent of this connector is to provide an input for sensors, but the connector can be used for output as well. Pin D4 is 5 volt tolerant so that a 5 volt sensor can be connected to it.

There are two 3-position terminal blocks shown at the upper left side of figure 2-6. The lower pin (pin 1) of each terminal block connects directly to a Photon pin: pin A0 for the sensor 1 block and pin A1 for the sensor 2 block. The remaining pins provide Photon 3.3 volts (NOT motor power 3.3 volts) and ground to external devices. The intent of these connectors is to provide

3.3 volt analog inputs to the Photon, using the 3.3 volt logic power for voltage divider power as needed (e.g. for resistive light sensors, force sensors, temperature sensors, etc.). However, the signals can also be configured as digital inputs (5 volt tolerant) and digital outputs, as required by the application.

2.6.2. Physical Connections.

All three terminal blocks are 3- position. Each terminal block has a signal connection that connects directly to a Photon I/O pin. One terminal block provides 5 volt logic power to external circuits and the other two terminal blocks provide Photon 3.3 volt logic (not motor) power to external circuits. All three terminal blocks provide a connection to ground.

2.6.3. Specifications.

Photon pin D4 can be used as a general purpose input. It is 5 volt tolerant when used as an input without the Photon's internal pullup or pulldown resistors. Pin D4 can be configured with a (nominally) 40K ohm pullup or pulldown resistor (internal to the Photon) but the maximum input signal is only 3.3 volts when one of these resistors is enabled. A contact switch can be connected to the signal and ground pins of the digital terminal block and the contact state (open or closed) can be sensed through D4 configured as INPUT_PULLUP. This signal can also be configured as a general purpose, 3.3 volt logic output.

Photon pins A0 and A1 can be used as either analog or digital inputs. When used as digital inputs, they are 5 volt tolerant but can be used to sense switch contacts when the pin is configured as INPUT_PULLUP (to the Photon's 3.3 volt supply). The nominal value of the Photon's internal pullup and pulldown resistors is 40 K ohms. When used as analog inputs, voltages between the 3.3 volt Photon supply and ground can be read out as calibrated 12 bit values, with 0 corresponding to ground and 4095 corresponding to the 3.3 volt supply. These pins can also be configured as general purpose, 3.3 volt logic outputs.

Note: The Photon's internal 3.3 volt regulator can supply a maximum of 100 ma to external 3.3 volt circuits. Care must be taken not to draw too much current from the 3.3 volt power connectors.

2.6.4. Applications.

There are numerous applications for these general purpose I/O pin connections. The Photon D4 connection is intended for sensing a door switch, limit switch or other digital contact using the Photon's internal pullup resistor. However, 5 volts and ground are provided on the D4 terminal block in order to power 5 volt logic breakout boards that either send 5 volt logic signals to the Photon or else accept 3.3 volt logic signals from the Photon.

Photon A0 and A1 connections provide the same capability as the D4 connection but they also can be used as analog inputs. To this end, their terminal blocks are supplied with the Photon's 3.3 volt logic power and ground. This way, a resistive voltage divider can be used to sense light levels (using an LDR), temperature (using a thermistor), force (using a force sensing resistor), water level (using resistive contacts) etc. Any of these types of analog sensors can be configured as a voltage divider with a fixed resistor, powered by the 3.3 volt and ground terminals.

2.7. Expansion.

The *Wireless I/O Board* provides an 8 pin expansion header; see figure 2-7.

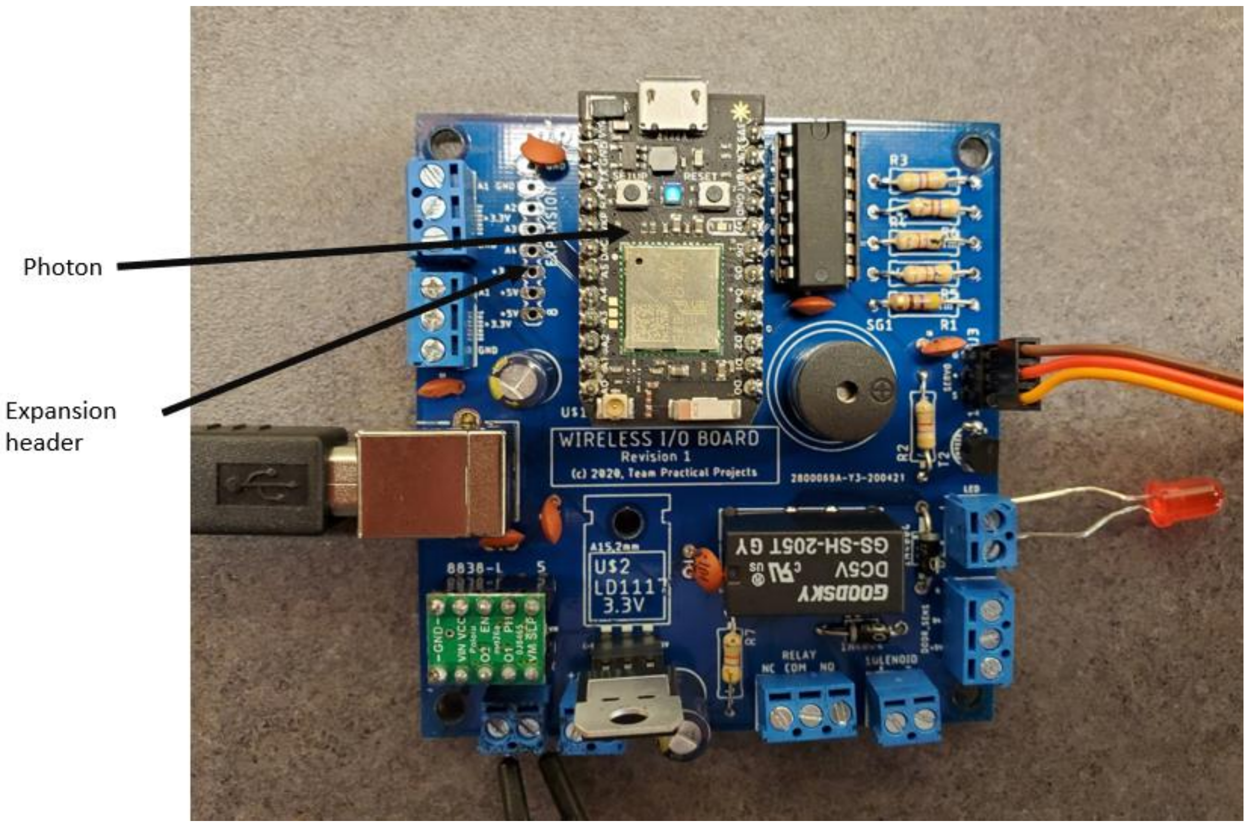

Figure 2-7. Expansion Header.

2.7.1. Functional Description.

The expansion header brings out the following signals to an 8 pin header:

- +5 volts: the Board power supply, from the Type-B USB power input.
- +3.3 volts: regulated 3.3 volt logic power from the Photon's on-board voltage regulator.

- GND: the Board ground
- A2, A3 and A4: Photon analog/digital I/O pins.

Use of the Expansion Header is optional. It is intended to provide external expansion to the *Wireless I/O Board*; e.g. via a secondary printed circuit board that is developed for some specific project.

2.7.2. Physical Connections.

An 8 pin header (0.1 “ pin spacing) provides the Expansion capability. Normally, an 8 pin male header strip would be soldered to these pins and a female-female jumper cable would be used to connect a secondary printed circuit board to these signals.

2.7.3. Specifications.

The GND pins connect to the Board ground plane and is the ground reference for all power and logic.

The +5 volt pins are connected to the Board’s 5 volt power bus which originates with the USB Type-B connector. The amount of current that can be drawn from this power source depends upon the input power supply to the Board but should not exceed 2 amps total.

The +3.3 volt pins are connected to the Board’s 3.3 volt logic power bus which originates at the Photon’s 3.3 volt regulator. A maximum of 100 ma may be drawn from the Photon. The maximum amount of power that can be drawn from the 3.3 volt power pins on the Expansion connector should not exceed 80 ma if the Small Motor Controller function is used and less if 3.3 volt power is drawn from the A0 and A1 terminal blocks.

The A2, A3, and A4 pins are directly connected to the corresponding pins on the Photon. See the Photon datasheet for details,

2.7.4. Applications.

The main application of the Expansion Connector is to expand the capabilities of the *Wireless I/O Board* via a ribbon cable connection to a secondary printed circuit board. The latter board can contain any circuitry that requires 5 volt or 3.3 volt logic power and can communicate with the Photon via the A2, A3, and A4 pins.

3. TEST AND DEMONSTRATION FIRMWARE.

3.1. Firmware Overview.

The file “locktest.ino” contains Photon firmware that can be used to exercise some of the functions of the *Wireless I/O Board.* This file can be found in the folder “Test_Firmware” in this GitHub repository. This firmware exposes three functions to the Particle Cloud. These functions can each be invoked using the Particle Console. For information about the Particle Console, see:

https://docs.particle.io/tutorials/device-cloud/console/

3.2. Firmware Installation

In order to install the test firmware on your Photon, you will need to compile and flash the file “locktest.ino” onto your Photon There are two ways to do this:

- Use the Particle Web IDE: Open a new project in the Web IDE and delete the default setup() and loop() templates. Open the file “locktest.ino” in this repository with any text editor or word processor program[5]. Now copy everything in the program and paste it into the blank template in the Web IDE. Be sure that all lines of “locktest.ino” are copied into the Web IDE window and save the program using any name that you wish. Next, use the Web IDE to select your target Photon and flash the code to it. For more information about the Particle Web IDE, see:

  https://docs.particle.io/tutorials/developer-tools/build/

- Use the Particle Workbench: Copy the file “locktest.ino” onto the computer where you are running the Particle Workbench. Use Workbench to compile and flash this code to your Photon. For more information about the Particle Workbench, see:

  https://docs.particle.io/tutorials/developer-tools/workbench/

The Web IDE approach is probably easier for someone who is new to Particle firmware development, as it is all web based. However, if you plan to develop firmware for Particle devices, we recommend that you install and learn the Workbench.

[5] When using a word processing program for this purpose, be sure that it is in plain text mode.

3.3. Exercising the Board Using the Particle Console.

Once the test firmware is flashed onto the Photon that is on your *Wireless I/O Board*, open the Particle Console by going to:

https://console.particle.io/

Log in to your Particle account to get to the Particle Console home screen. Select the "Devices" icon on the right hand side of the screen to see a list of the Particle devices that are in your account. Select the Photon device that is on your *Wireless I/O Board*. Make sure that the Board is powered up and that the Photon's multicolor LED is breathing Cyan, indicating that it is connected to the Particle Cloud and running the firmware that you previously flashed to it.

After selecting the Photon device, you will get a Device screen. You should see three functions at the lower left hand side of the screen, similar to figure 3-1.

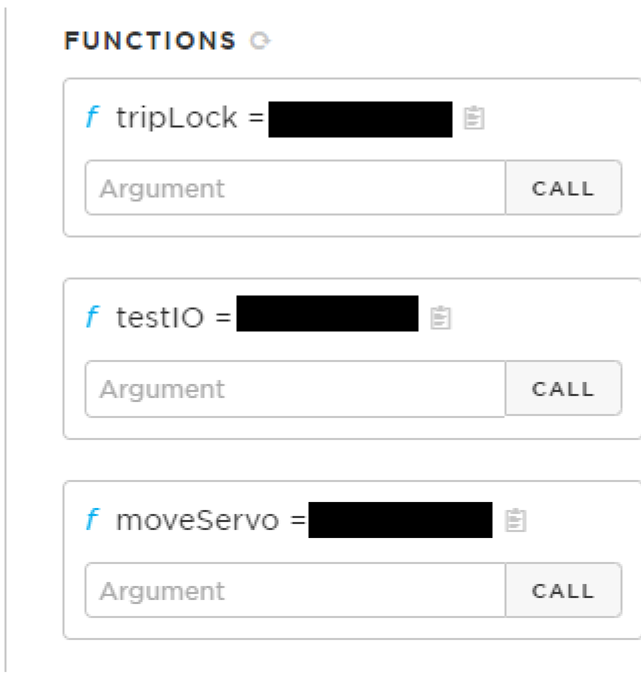

Figure 3-1. Cloud Functions for the Test Firmware.

You can then test these functions on your *Wireless I/O Board*, as follows:

- <u>tripLock</u>: The Cloud function "tripLock" requires no argument, so leave the "Argument" field blank. Selecting CALL activates this function on the Photon. The function exercises a small motor connected to the Motor Terminal Block. The function first pulses the motor to move in one direction for a total of 30 ms and then stop. The function waits for two seconds and then pulses the motor for 30 ms in the opposite direction. The motor that we are using for this test is part of the Tokatuker Cabinet Lock that we modified to be controlled via the Wireless I/O Board:

> https://www.amazon.com/Tokatuker-Electronic-Cabinet-Hidden-Drawer/dp/B075QF1VPR

Pulsing this motor for 30 ms causes the shaft of this particular motor to turn approximately 180 degrees.

- testIO: The Cloud function “testIO” requires no argument, so leave the “Argument” field blank. Selecting CALL activates this function on the Photon. The function sounds the on-board buzzer, activates the external LED and activates the on-board relay; all for two seconds. After two seconds, all of these parts are deactivated. In order to test these parts of the Board, connect an external LED to the external LED terminal block and use a multimeter or other device to measure voltage across the Solenoid Terminal Block connectors and to measure resistance across the Relay Terminal Block connectors. The buzzer should sound for two seconds, the LED should light for the same two seconds, the solenoid voltage should go from zero to 3.3 volts (or whatever voltage is the Motor Power) for the same two seconds, the relay resistance between COM and NO should go from infinity to zero for the same two seconds, while the relay resistance between COM and NC should go from zero to infinity for the same two seconds.

- moveServo: The Cloud function “moveServo” requires an argument – an argument of “0” moves the servo to a position of 5 degrees, and any other argument (including no argument) moves the servo to a position of 85 degrees. Selecting CALL activates this function on the Photon. Make sure that you have a hobby servo properly plugged in to the Servo pin header connector when testing using this function.

You might also wish to flash the Particle “Tinker” firmware to your Photon and use the Particle Tinker App to exercise functions on the Board directly via the Photon’s pins.