Robot Metabolism:
How to Build a Robot Link

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Creative Machines Lab

Columbia University, New York, NY 10027, USA

Prepared by:

Nihar Niraj Garg

Master of Science, Mechanical Engineering

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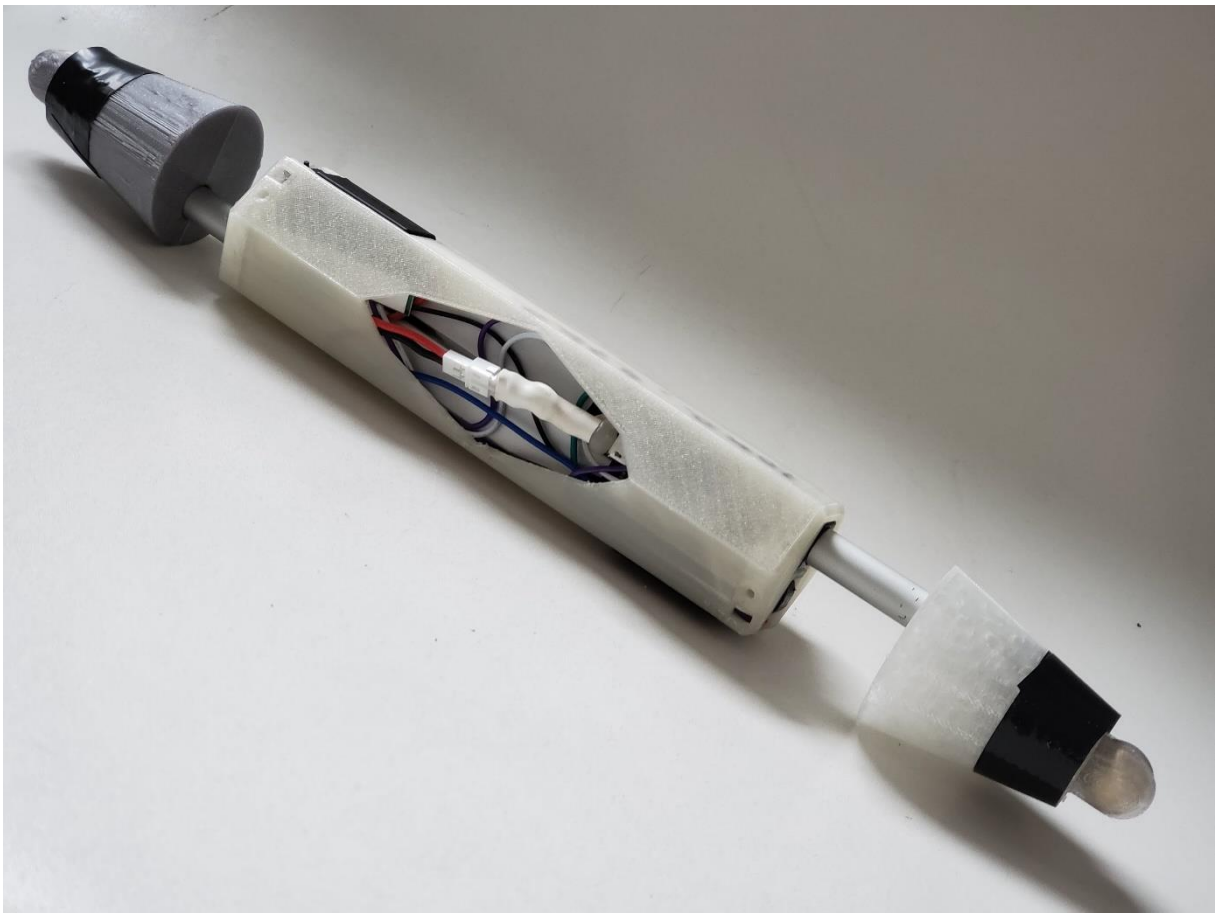

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Manufacturing 3D printed parts

1. Download CAD files for the shell and connectors from below link: https://drive.google.com/drive/folders/16bh49vLKTE-smqErBDeFmtQjXsHXh2o3?usp=sharing
2. Use Glow-in-the-Dark filament
3. Adjust Ender 3 Pro print settings as necessary to get a clean print with new filament
    a. Increase print temperature from 200 degrees C to 215 degrees C
    b. Set build plate temperature to 60 degrees C
    c. Reduce print speed to 40 mm/s
    d. Oriented print 45 degrees
4. Use sandpaper to smoothen out any uneven print surfaces

Build Preparation

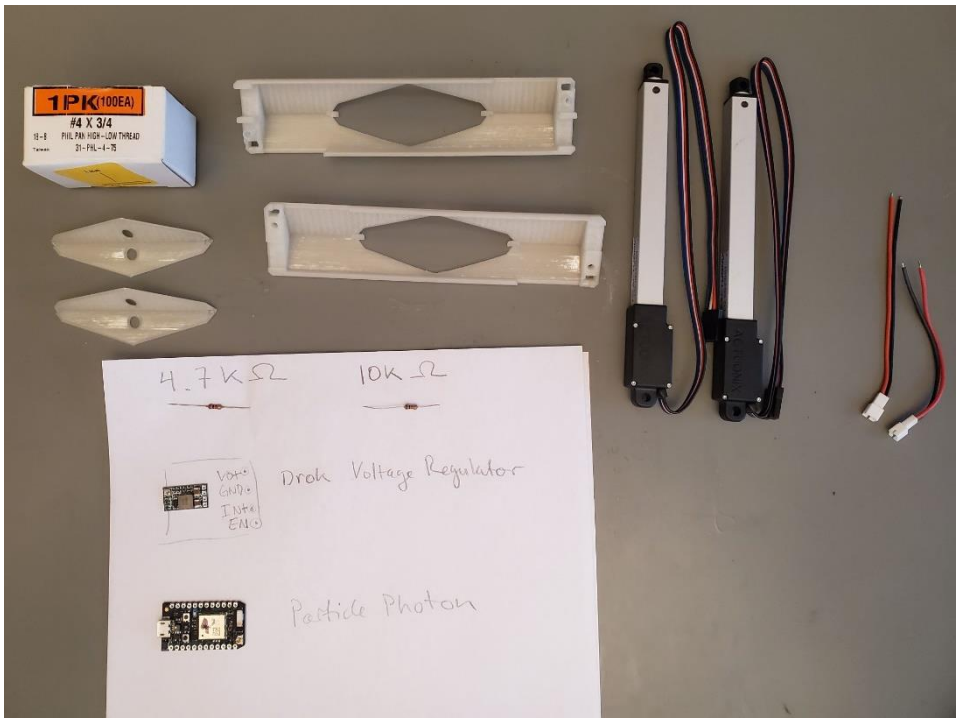
Partlist

Robot Link

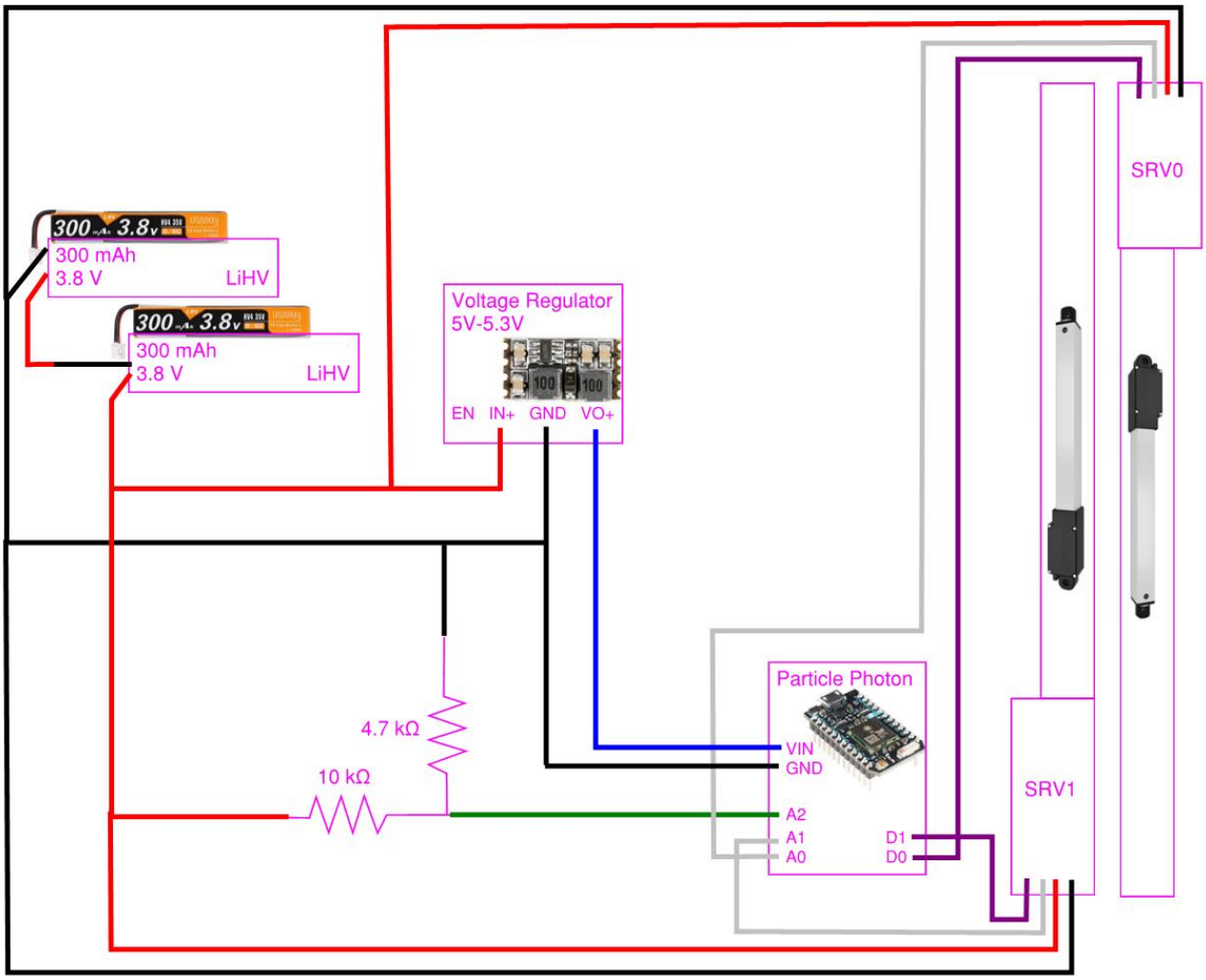
1. 3D printed Body-Shell (Top & Bottom) and 2 x Cover
2. 2 x Actuonix L-12I
3. Particle Photon
4. 2.4GHz Mini Flexible WiFi Antenna with uFL Connector - 100mm
5. Drok Voltage Regulator
6. 4.7 kOhm Resistor
7. 10 kOhm Resistor
8. 2 x JST-PH 2.0 Female harness
9. Heat-Shrink Tubing
10. 24 AWG stranded wire
11. 2 x Stainless Steel Rounded Head Thread-Forming Screws for Brittle Plastic
12. Electrical Tape

Connector

1. 2 x 3D printed Connector-Shell (Top & Bottom) and Magnet Holder
2. Confined-Space Conical Compression Spring 0.75” L, 0.6” x 0.375” OD
3. Neodymium magnet sphere 1/2” diameter



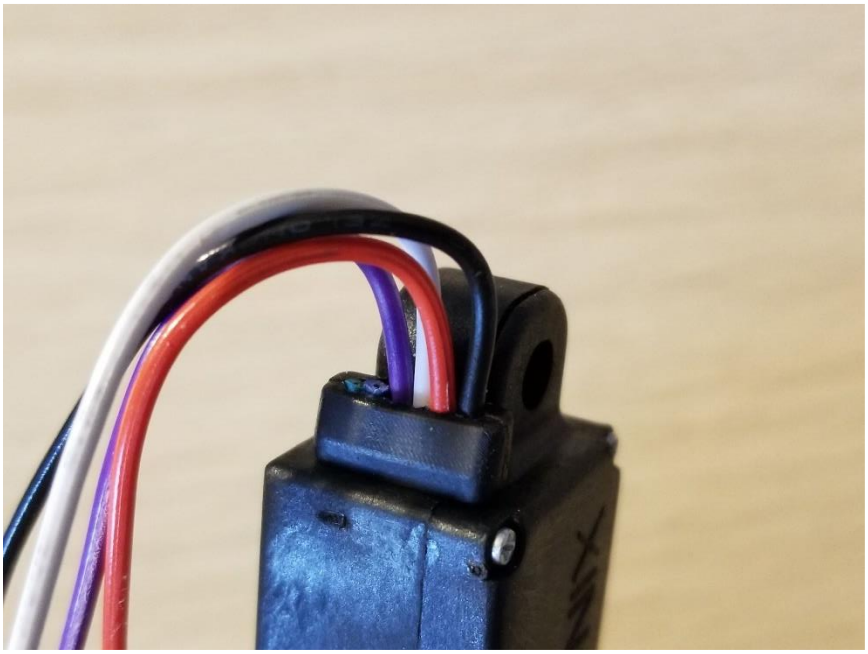
Circuit Diagram

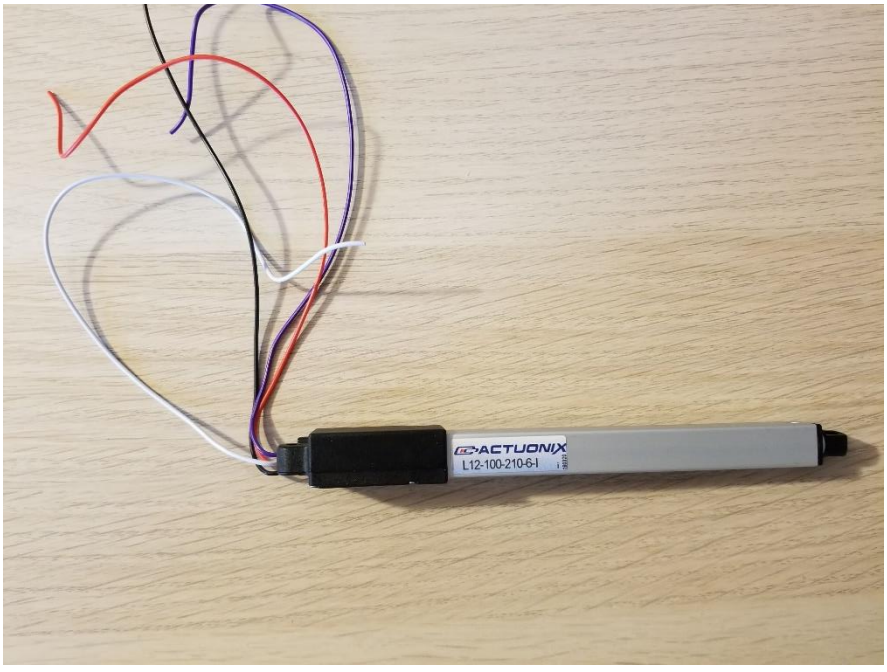


Getting the Components Together

Actuators

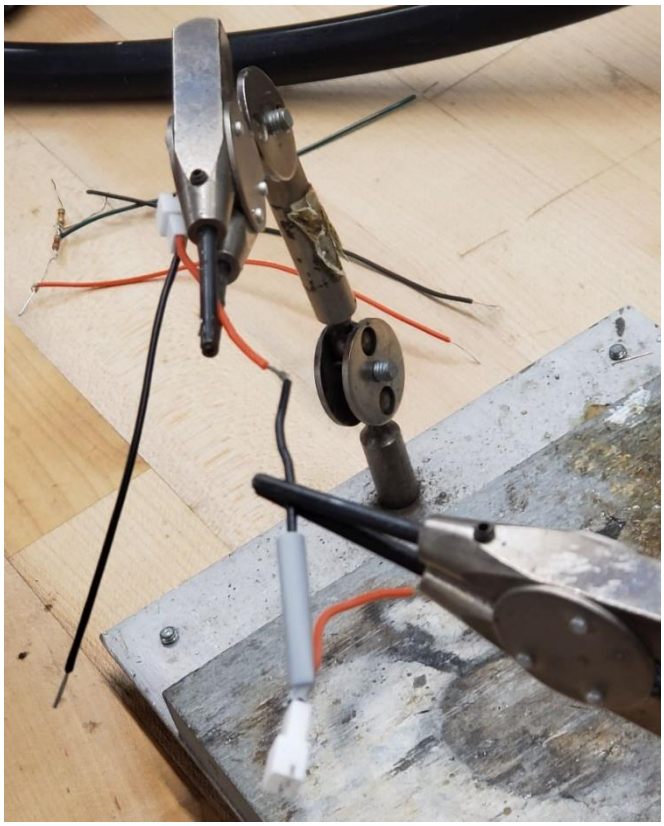
1. Cut green and blue wires flush with the actuator housing and save them for future use. For the rest of this assembly, we will only be using these wires.
2. Separate the remaining 4 wires (black, red, white, purple).
3. Cut the red and black wires in half for future use.

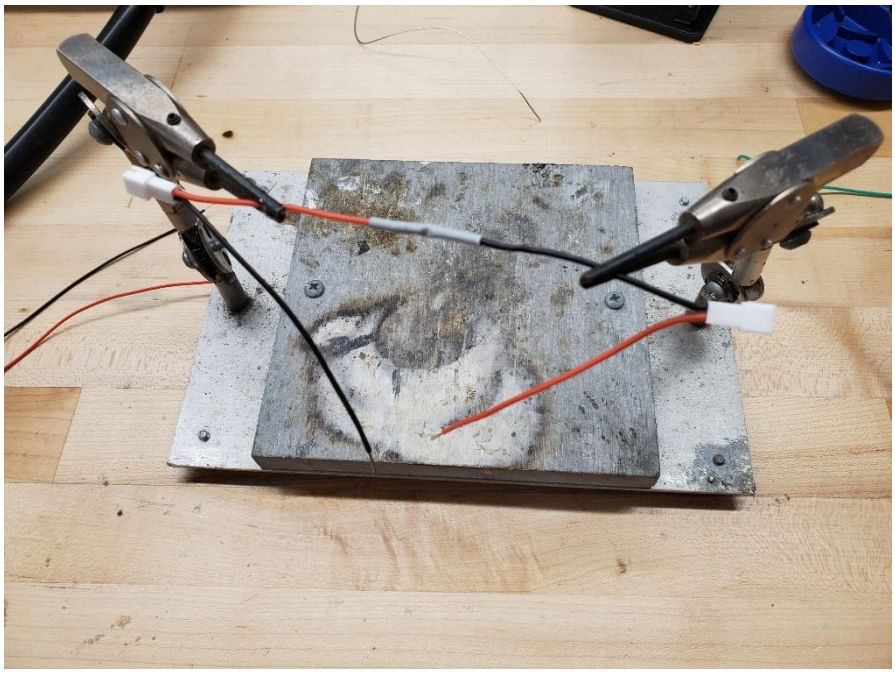




Battery Harness

1. Cut the red wire from one JST-PH 2.0 Female harness and the black wire of the other JST-PH 2.0 Female harness to 5cm in length.
2. Put heat shrink tubing around one end of the wires to be soldered.
3. Solder the shortened red wire from one JST-PH 2.0 Female harness to the shortened black wire of the other JST-PH 2.0 Female harness.
4. Heat the tubing so it conforms to the wires.

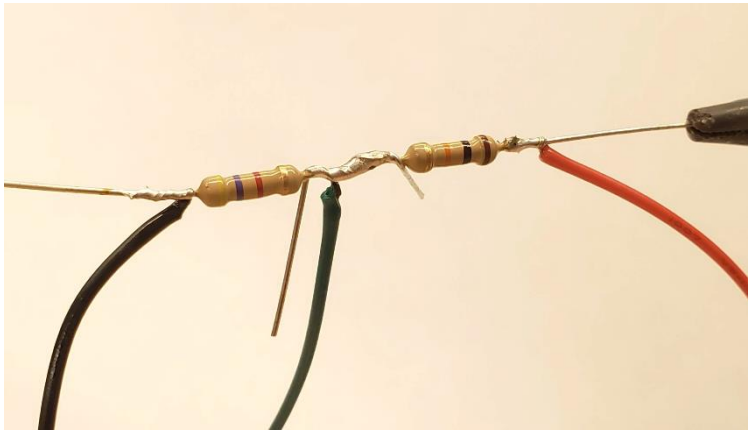




Voltage Divider

1. Solder the resistors and wires as per the circuit diagram (red wire to 10 kOhm, black wire to 4.7 kOhm and green in the middle).

2. Arrange the wires such that the red and black wires are on one side and the green wire is on the other.



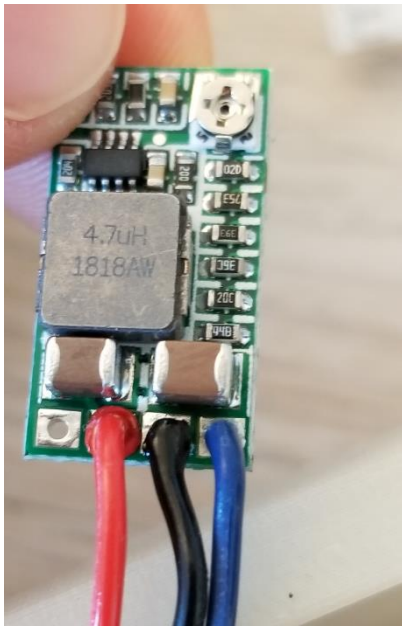
3. Clip all excess wire and sharp corners to prevent them from puncturing the heat shrink.

4. Pull heat shrink tubing over the soldered resistors.

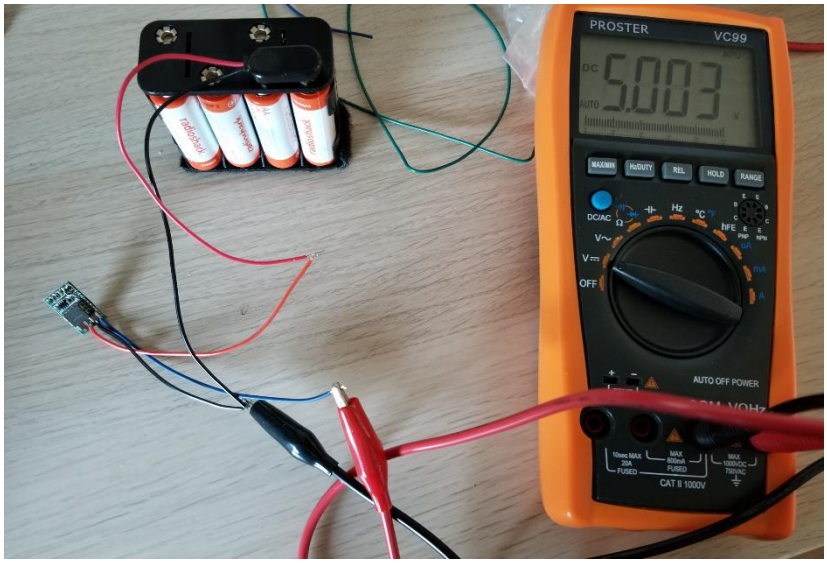
5. Heat the tubing so it conforms to the wires and resistors.

Voltage Regulator

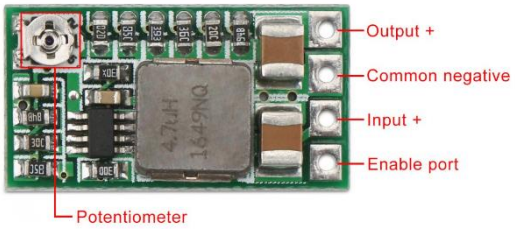
1. Solder the blue wire to the VO+ port.
2. Solder the black wire to the GND port.
3. Solder the red wire to the IN+ port.



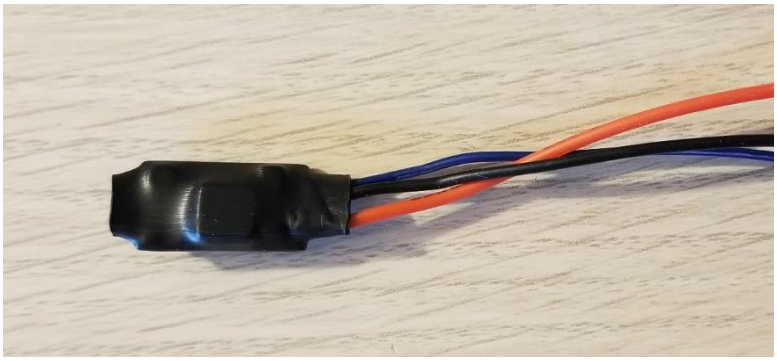
4. Connect the red wire of the combined JST-PH 2.0 Female harness to the red wire of the Voltage Regulator
5. Connect the black wire of the combined JST-PH 2.0 Female harness to the black wire of the Voltage Regulator
6. Connect the black prong of the Multimeter to the black wire of the Voltage Regulator
7. Connect the red prong of the Multimeter to the blue wire of the Voltage Regulator
8. Connect the batteries to the female harness to apply between 7-9V DC
9. Turn on Multimeter and set the read setting to DC Voltage



10. Adjust Voltage Regulator potentiometer with Philips screwdriver to make the output to 5V



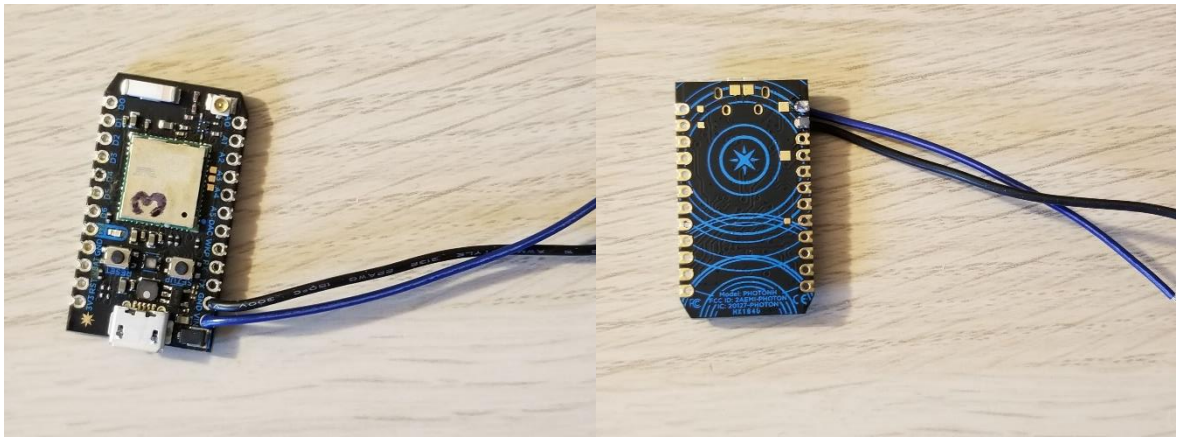
11. Pull heat shrink tubing over the voltage regulator.
12. Heat the tubing so it conforms around the voltage regulator.



Particle Photon

Note: This step can be deferred until later in the assembly process to better help gauge the wire lengths

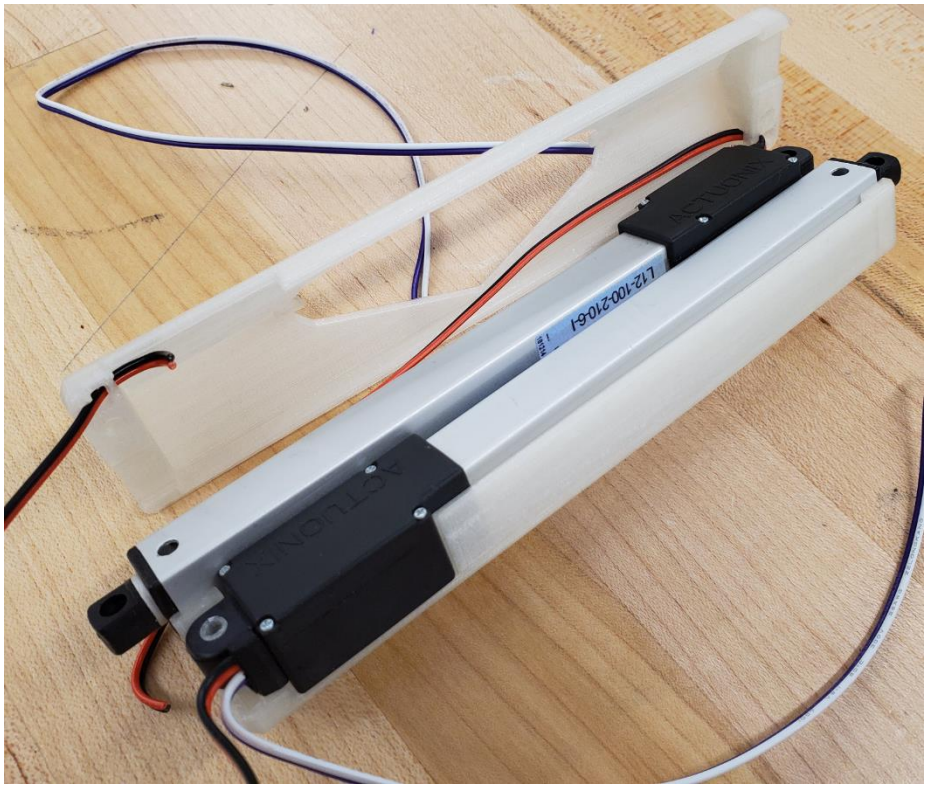
1. Solder the blue wire from the voltage regulator onto the VIN port.
2. Solder the black wire on the GND port.



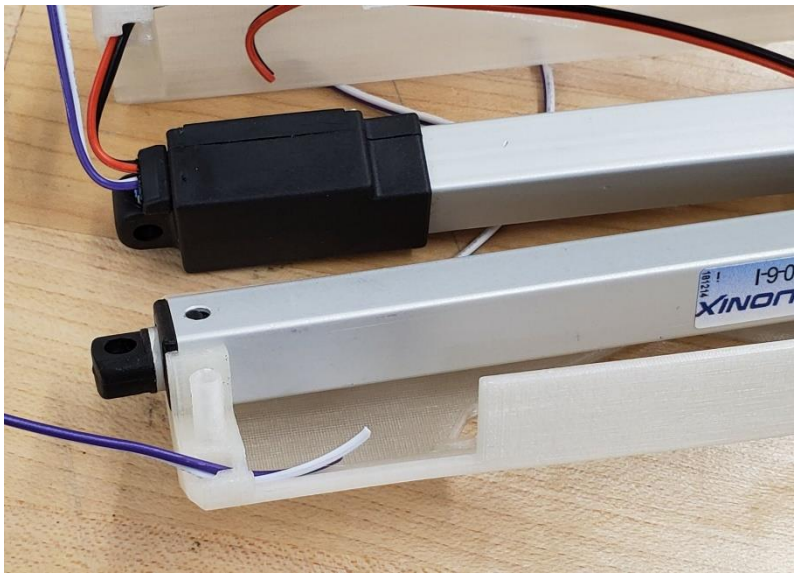
Assembly

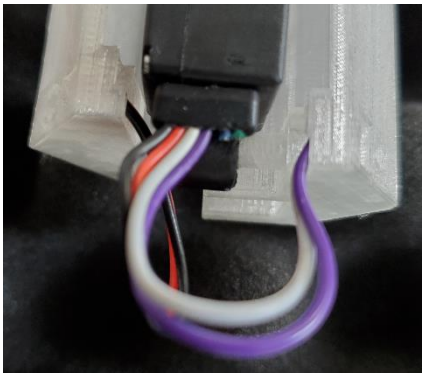
Actuator into shell

1. Loosely place the actuator into the 3D printed shell's screw hole with the head of the actuator facing out.



2. Pull the red and black wire through the wire hole in the shell closest to it (from outside to inside).
3. Pull the purple and white wire through the wire hole in the shell closest to it (from outside to inside).



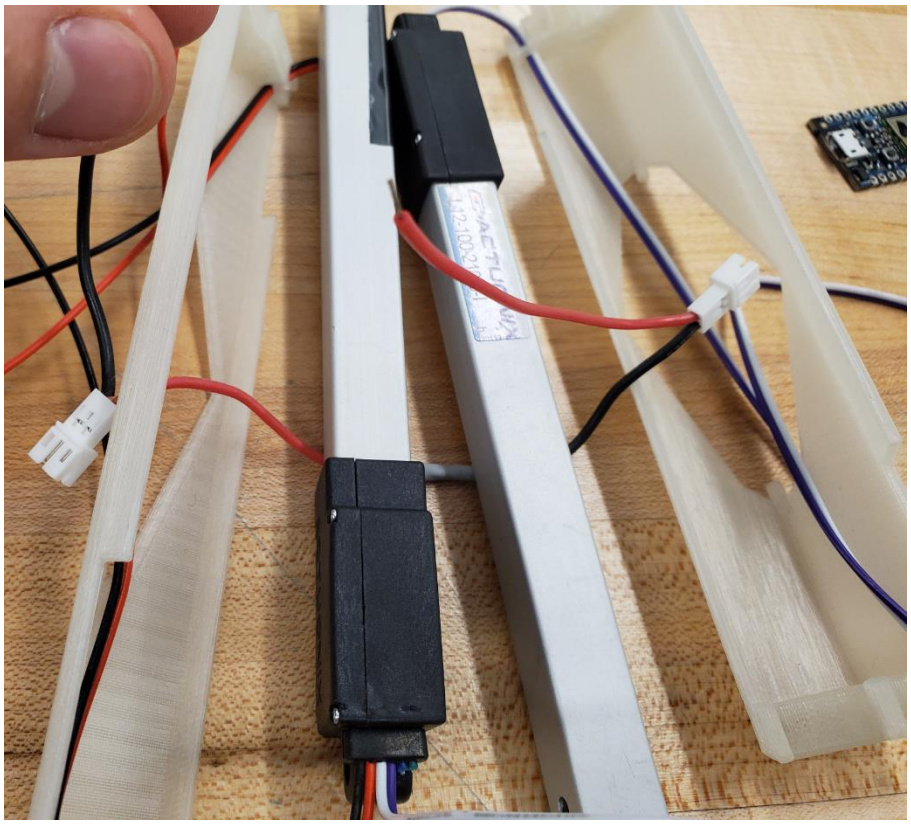


Photon Placement

1. Choose one end of one of the actuators and put a 40x22mm strip of electrical tape on it.
2. This actuator is SRV0.

Wire Routing

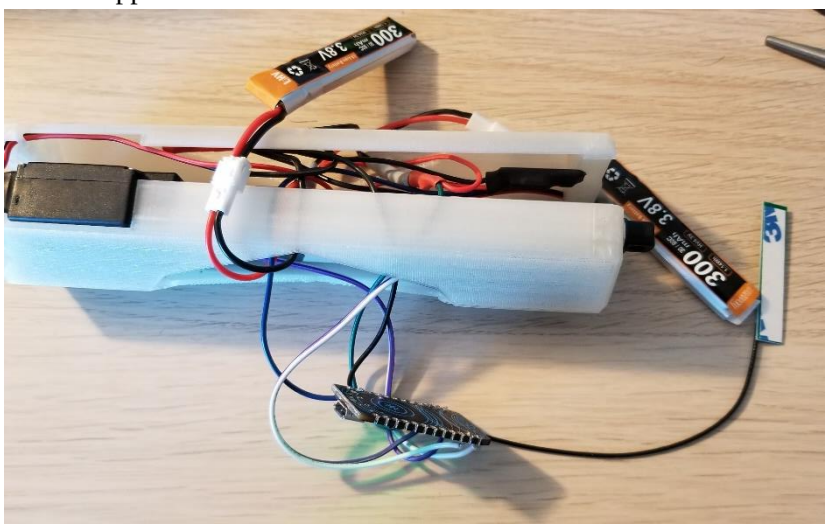
1. Route the battery connectors inside the shell but under the actuators.



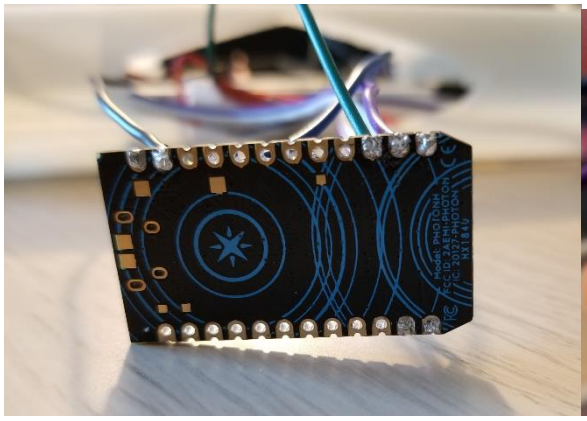
2. Cut the green wire from the Voltage Divider to 12cm in length.
3. Cut the red and black wires from the Voltage Divider to 5cm in length.
4. Cut the red and black wires from the Actuators to 12cm in length.
5. Cut the black wire from the Particle Photon to 12cm in length.

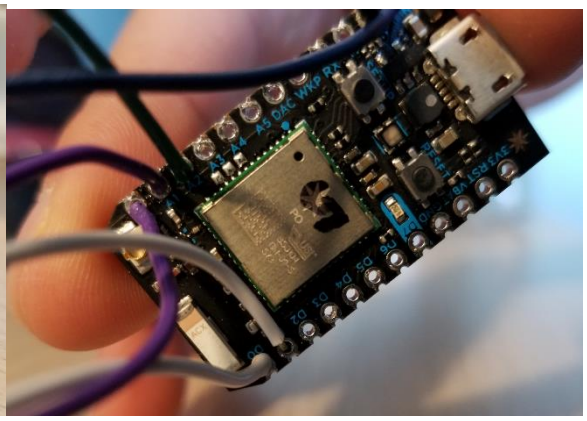
Put the link together

1. Neatly assemble all components inside the shells.
    a. One battery on each side to maintain balance
    b. The Voltage Regulator and Voltage Divider should be on the opposite side of the Photon and opposite side of the shell.

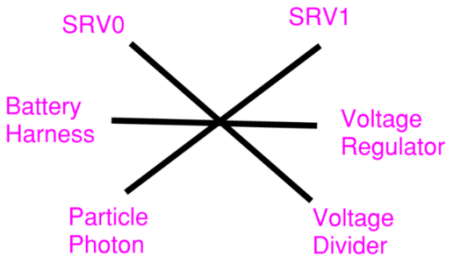


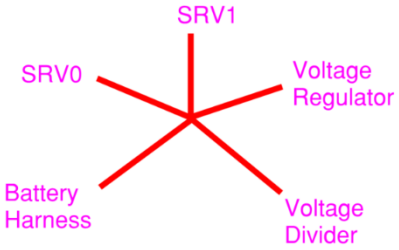
2. Orient the Particle Photon so that the USB Port is facing the opening.
3. Solder the wires to the Photon as per the Circuit Diagram.
    a. Solder the White and purple wire from SRV0 to the A0 and D0 ports respectively.
    b. Solder the White and purple wire from SRV1 to the A1 and D1 ports respectively.
    c. Solder the Green wire from the Voltage Divider to the A2 port.



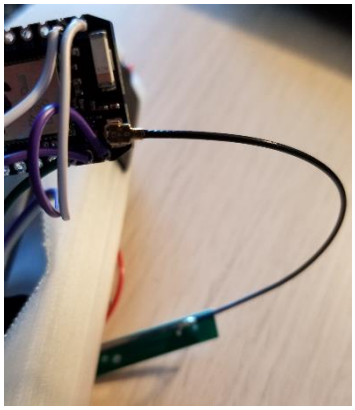


4. Solder the remaining loose black and red wires as per the Circuit Diagram. Use the below images as reference.
    a. Remember to place heat shrink around one of the wires before soldering. Once soldered, heat the tubing so it conforms to the wires.





5. Carefully Connect WiFi Antenna to the Particle Photon (be careful not to damage the connector) .
6. Place the antenna inside the shell, off to the side.

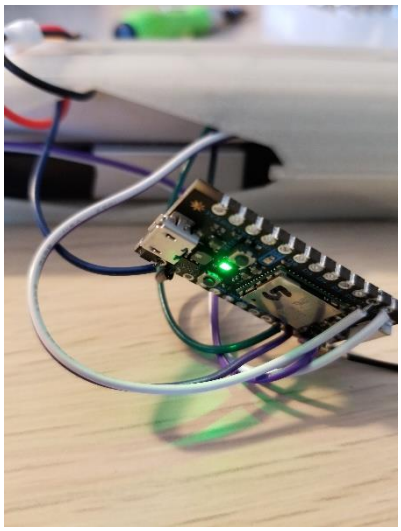


7. Screw the shells together using the 2 x Thread-Forming Screws.
8. Secure the links by placing the 3D printed shell covers in their respective openings.

Testing

Test Wiring and Components

1. Plug in batteries
2. Photon LED should flash



Test Links

1. Navigate to Particle Web IDE: https://build.particle.io/build/new
2. On the bottom left hand ribbon, choose “Devices”
3. Select the number of the Photon you are working with (should be written on the device)
    a. If not written then select “Add New Device” and set up the Photon as a new device
4. Select the photon “to flash”
5. Navigate to the Code section
6. Select the testlinks-hardwareteam.ino firmware: https://build.particle.io/build/606ddbdbde63ee0017f5c0d3
7. On the top left, flash firmware to the Particle
8. Both actuators should extend one at a time

TestLinks-HardwareTeam.ino

```
/*********
 * Modular Robot Control
 * Simple Inch Worm Gate
 * *******/
int move_wait_time = 140;

Servo srv0;
Servo srv1;

int srv0_sens = 0;
int srv1_sens = 0;
int voltage_raw = 0;
int srv0_pos = 0;
int srv1_pos = 0;

int MIN_NON_DETATCH_VAL = 60;
// temporarytest variables
int pos;

void setup() {
  // attaches the servo on the A4,A5 pin to a servo object
  srv0.attach( D0 );
  srv1.attach( D1 );
  srv0.write(MIN_NON_DETATCH_VAL);
  srv1.write(MIN_NON_DETATCH_VAL);
  delay(8000);

  // readout of position
  srv0_sens = analogRead( A0 ); // attach position readout of SRV0
  srv1_sens = analogRead( A1 ); // attach position readout of SRV1

  // readout voltage value
  voltage_raw = analogRead( A2 ); // readout raw voltage value

  Particle.variable(  "srv0_sens" , &srv0_sens , INT );
  Particle.variable(  "srv1_sens" , &srv1_sens , INT );
  Particle.variable(  "voltage_raw" , &voltage_raw , INT );

}

void read_analog_inputs(){
      srv0_sens = analogRead(A0);  // read the analogPin
      srv1_sens = analogRead(A1);  // read the analogPin
      voltage_raw = analogRead( A2 ); // readout raw voltage value
}

void loop() {
```

```
  // expand SRV0
  for(pos = MIN_NON_DETATCH_VAL; pos < 180; pos += 1)  // goes from 0 degrees to 180 degrees
  {                                  // in steps of 1 degree
    srv0.write(pos);              // tell servo to go to position in variable 'pos'
    read_analog_inputs();
    delay(move_wait_time);                    // waits 15ms for the servo to reach the position
  }
  // expand SRV1 and contract SRV0
  for(pos = MIN_NON_DETATCH_VAL; pos < 180; pos += 1)  // goes from 0 degrees to 180 degrees
  {                                  // in steps of 1 degree
    if ((180-pos) > MIN_NON_DETATCH_VAL){
      srv0.write(180-pos);              // tell servo to go to position in variable 'pos'
    }
    srv1.write(pos);              // tell servo to go to position in variable 'pos'
    read_analog_inputs();
    delay(move_wait_time);                    // waits 15ms for the servo to reach the position
  }
  // Contract SRV1
  for(pos = 180; pos>=MIN_NON_DETATCH_VAL; pos-=1)     // goes from 180 degrees to 0 degrees
  {
    srv1.write(pos);              // tell servo to go to position in variable 'pos'
    read_analog_inputs();
    delay(move_wait_time);                    // waits 15ms for the servo to reach the position
  }

  //contract links
  srv0.write(0);
  srv1.write(0);
  delay(15000);                    //give user 15 seconds to unplug battery
}
```