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# **Muscle BioAmp Shield**

**Upside Down Labs**

**May 13, 2024**

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v0.3

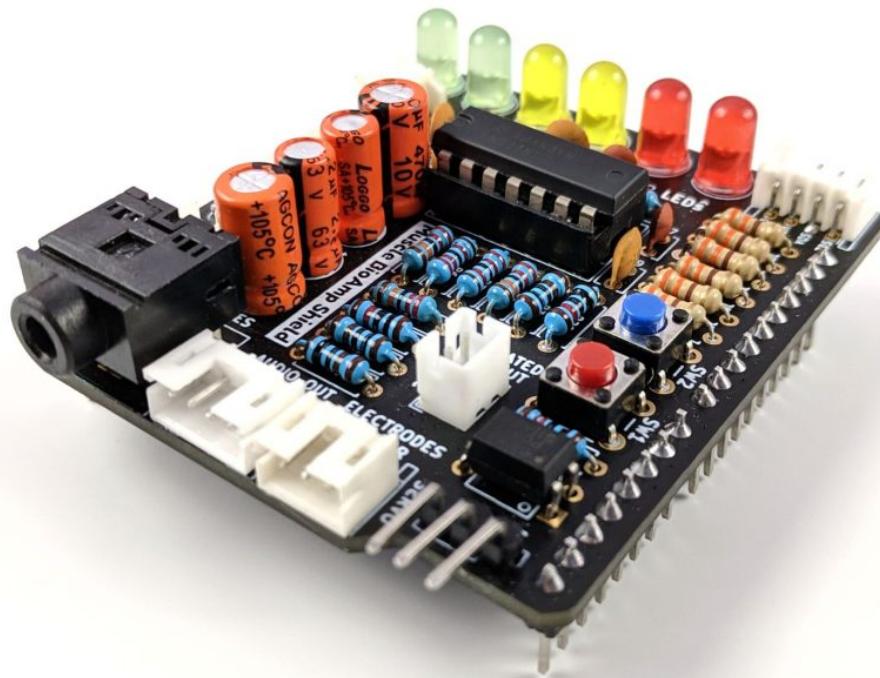
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**CHAPTER  
ONE**

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**OVERVIEW**

Muscle BioAmp Shield is an all-in-one Arduino Uno ElectroMyography (EMG) shield for learning neuroscience with ease which is inspired from BackYard Brains (BYB) [Muscle Spiker shield](#) and provides similar features like hobby servo output, user buttons, LED Bar, Audio output, and battery input. It is perfect for beginners as they can easily stack it on top of Arduino Uno to record, visualize and listen to their muscle signals to make amazing projects in the domain of Human-Computer Interface (HCI).



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**CHAPTER  
TWO**

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## **FEATURES & SPECIFICATIONS**

Muscle BioAmp Shield comes with various plug-and-play options so you can connect hundreds of extension boards like OLED screens, character displays, accelerometers, and servo controllers to name just a few using the STEMMA I2C interface. You also get STEMMA digital and STEMMA analog ports. On STEMMA analog port you can connect additional BioAmp EXG Pill or any other sensor with analog output. On STEMMA digital port you can connect any digital sensor or actuator of your choice.

Input Voltage	5V
Input Impedance	10^11 ohm
Fixed Gain	x2420
Bandpass filter	72 – 720 Hz
Compatible Hardware	Arduino UNO
BioPotentials	EMG (Electromyography)
No. of channels	1
Electrodes	3 (Positive, Negative, and Reference)
Dimensions	6.0 x 5.3 cm
Open Source	Hardware + Software

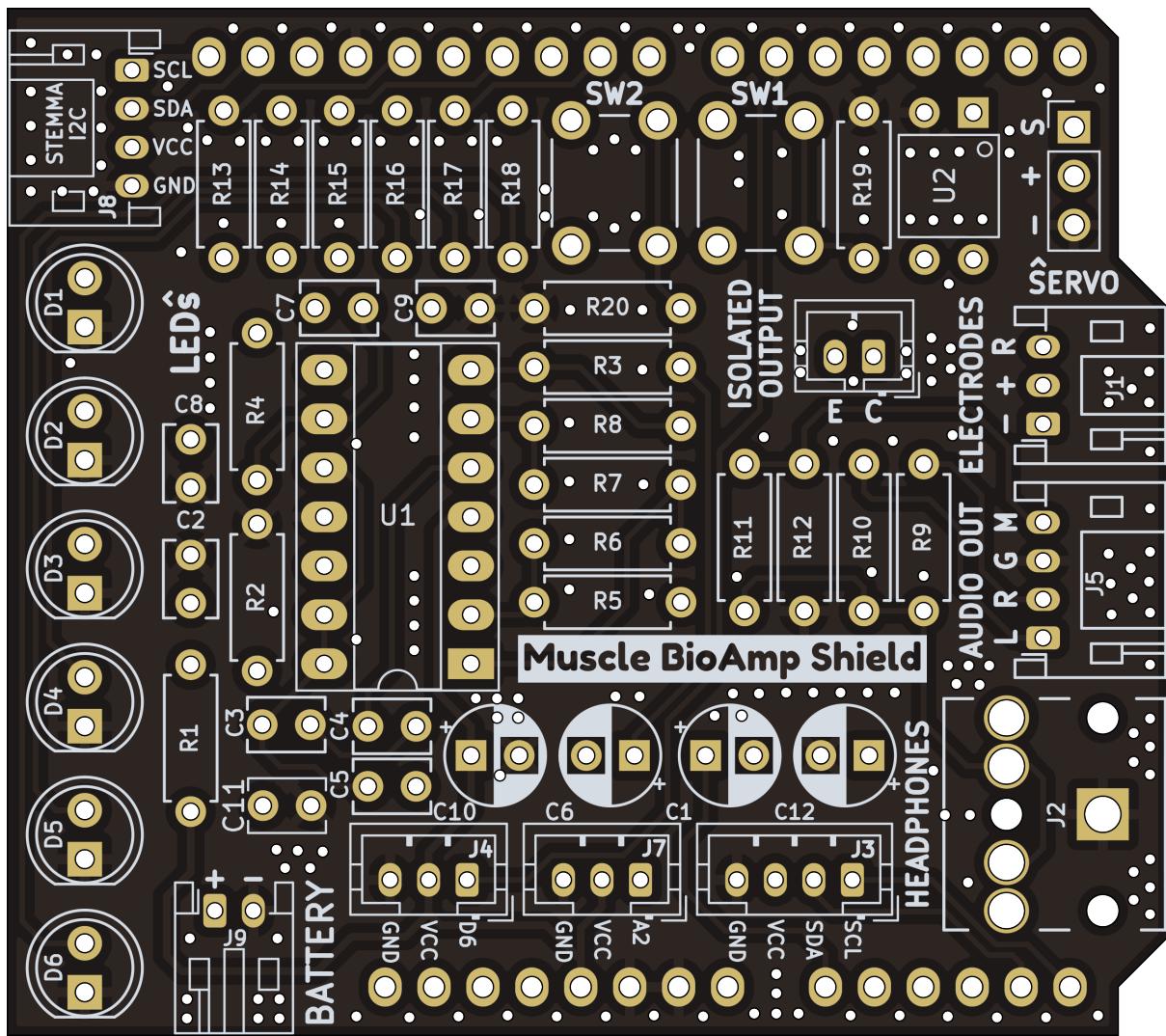
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## HARDWARE

Images below shows a quick overview of the hardware design.

### PCB Front



### PCB Back



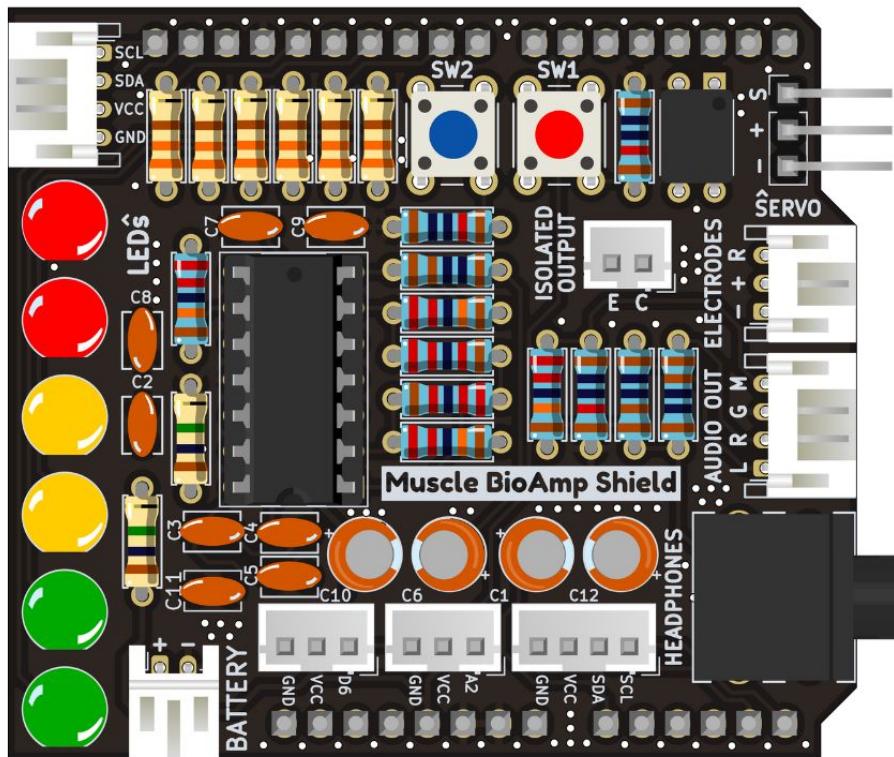


Fig. 1: Assembled PCB

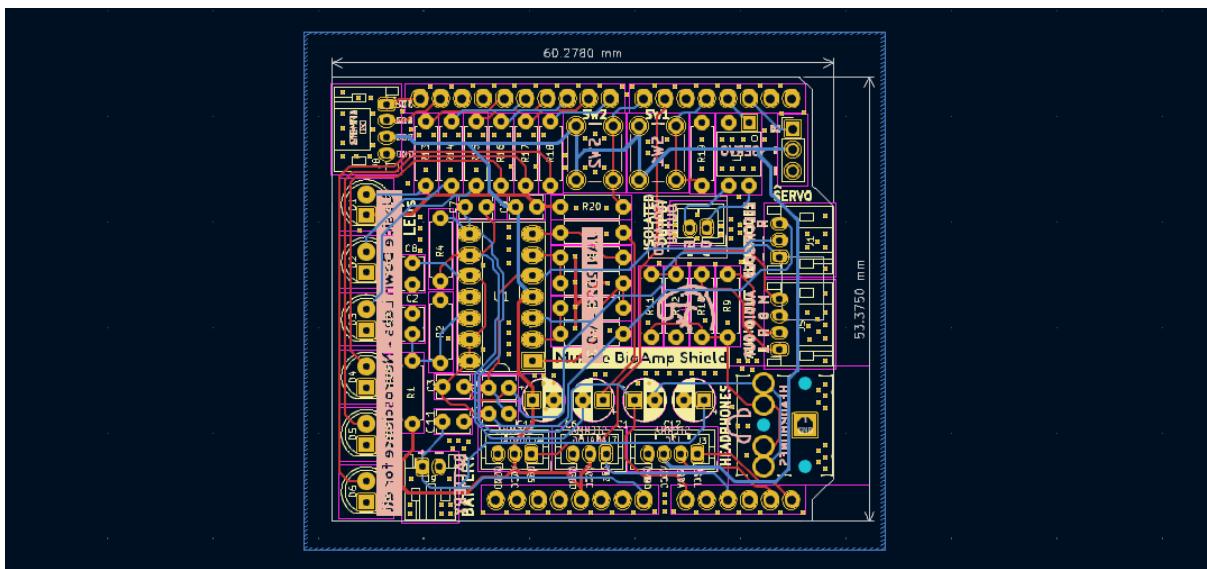


Fig. 2: PCB Layout

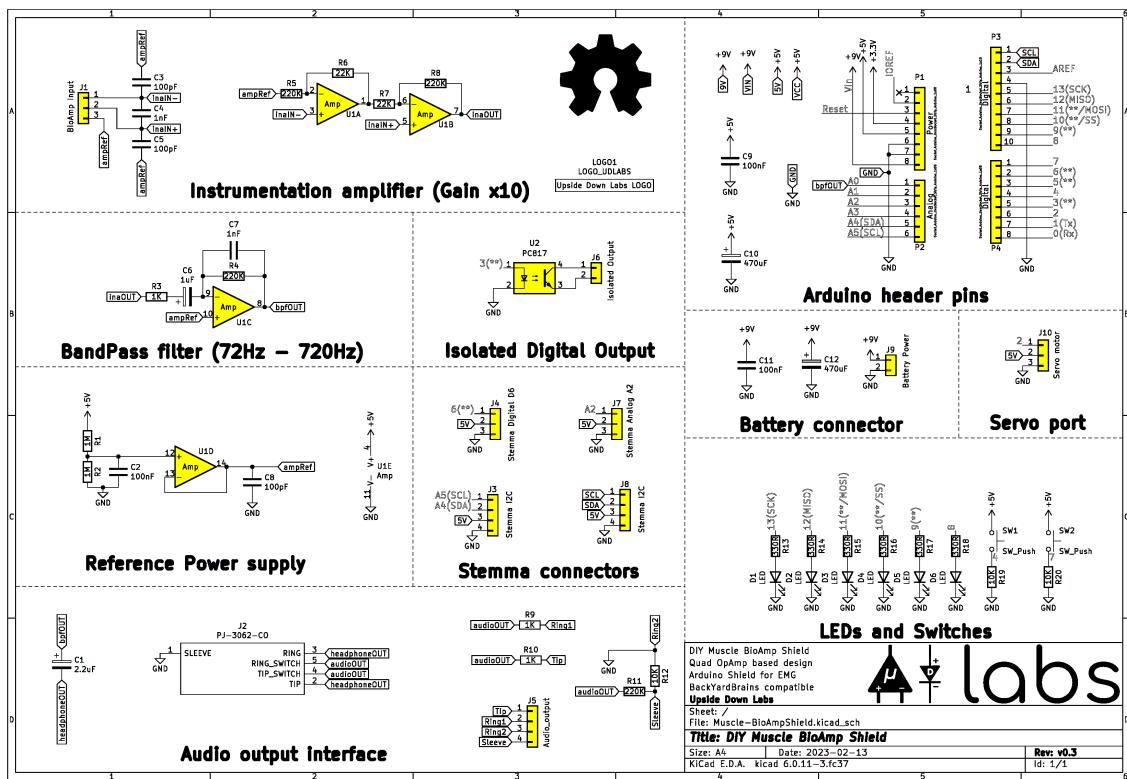


Fig. 3: Schematic Diagram

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**CHAPTER  
FOUR**

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## **CONTENTS OF THE KIT**

There are 2 variants available for Muscle BioAmp Shield v0.3 kit - one comes with the shield assembled and the other one contains bare PCB of the sensor and the components separately which you can assemble pretty easily.

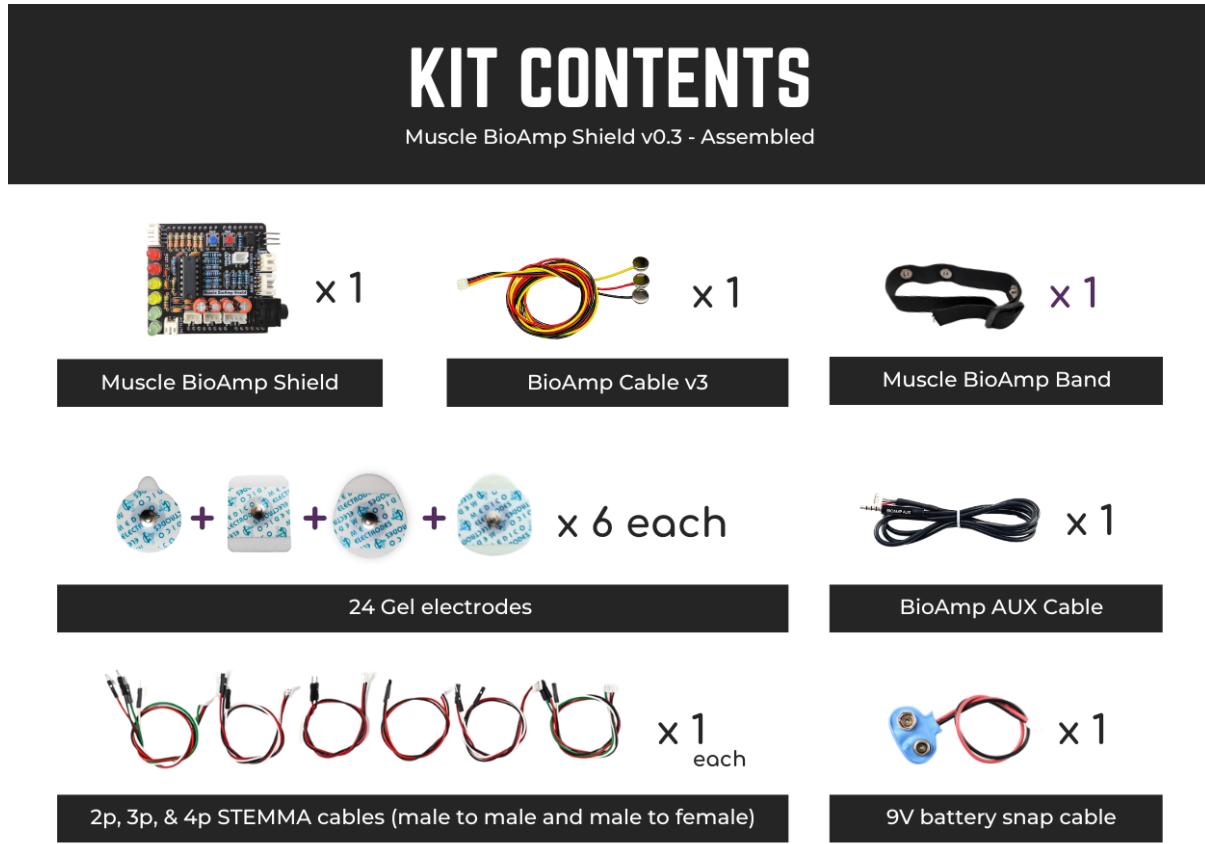


Fig. 1: Assembled Muscle BioAmp Shield kit content

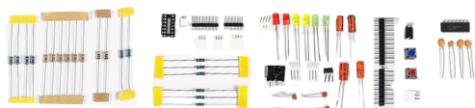
<https://youtu.be/w8yw12SUe6Q>

# KIT CONTENTS

Muscle BioAmp Shield v0.3 - Unassembled



x 1



Components



x 1



x 6  
each



x 1



x 1



x 1  
each

2p,

3p,

& 4p

STEMMA cables (male to male and male to female)



x 1

9V battery snap cable

Fig. 2: Unassembled Muscle BioAmp Shield kit content

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## CHAPTER FIVE

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# SOFTWARE REQUIREMENTS

Before you start using the kit, please download [Arduino IDE v1.8.19 \(legacy IDE\)](#). Using this you'll be able to upload the arduino sketches on your development board and visualise the data on your laptop.

### Legacy IDE (1.8.X)



### Arduino IDE 1.8.19

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used with any Arduino board.

Refer to the [Arduino IDE 1.x documentation](#) for installation instructions.

SOURCE CODE

Active development of the Arduino software is [hosted by GitHub](#). See the instructions for [building the code](#). Latest release source code archives are available [here](#). The archives are PGP-signed so they can be verified using [this](#) gpg key.

#### DOWNLOAD OPTIONS

**Windows** Win 7 and newer  
**Windows** ZIP file  
**Windows app** Win 8.1 or 10 

**Linux** 32 bits  
**Linux** 64 bits  
**Linux** ARM 32 bits  
**Linux** ARM 64 bits

**Mac OS X** 10.10 or newer  
[Release Notes](#)  
[Checksums \(sha512\)](#)

## ASSEMBLING THE KIT

You can get your own Muscle BioAmp Shield bag of parts from our [online stores](#) (shipping worldwide) and for assembling your shield you can take a look at [this interactive BOM](#) or the step by step guide below.

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**Note:** Follow the highlighted yellow shapes to assemble your shield!

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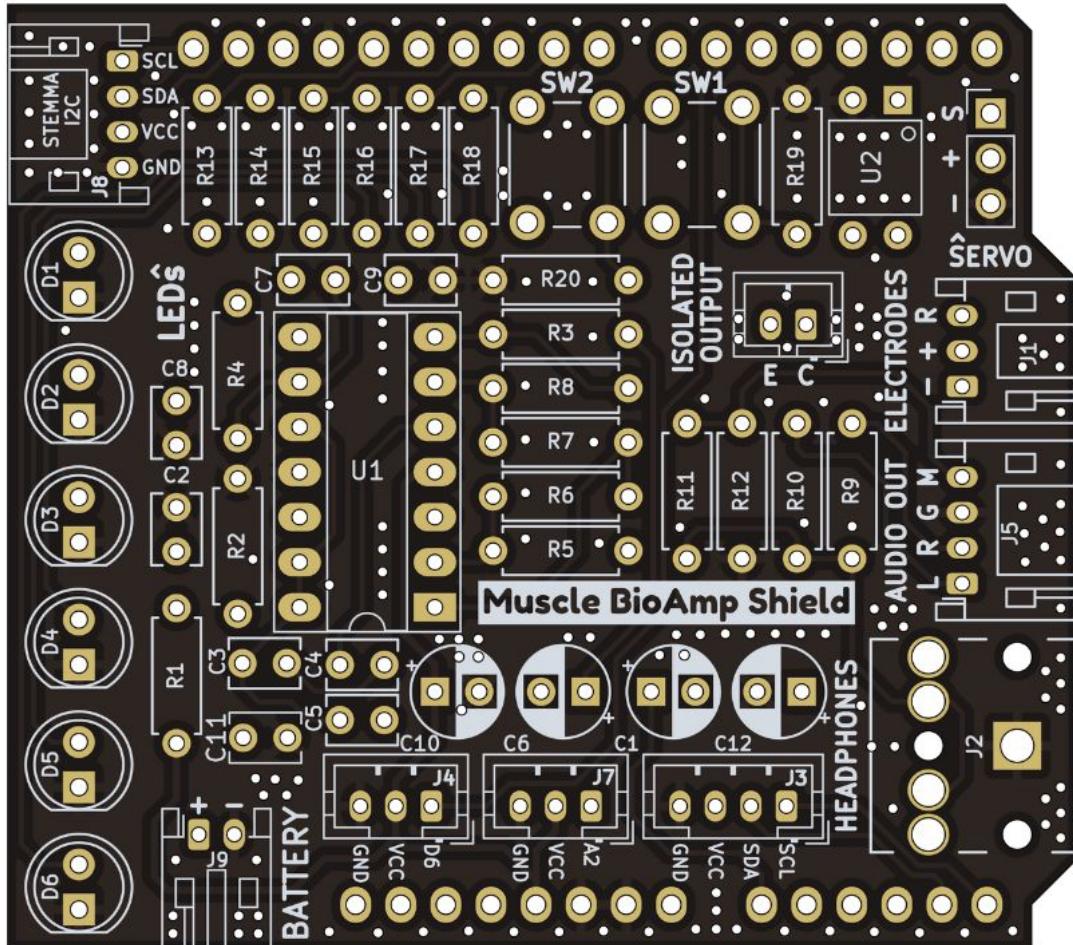


Fig. 1: Step 1 - Bare Board

Still can't figure out the assembly? You can follow the video provided below to assemble your Shield.

<https://youtu.be/dcuCihh3yn4>

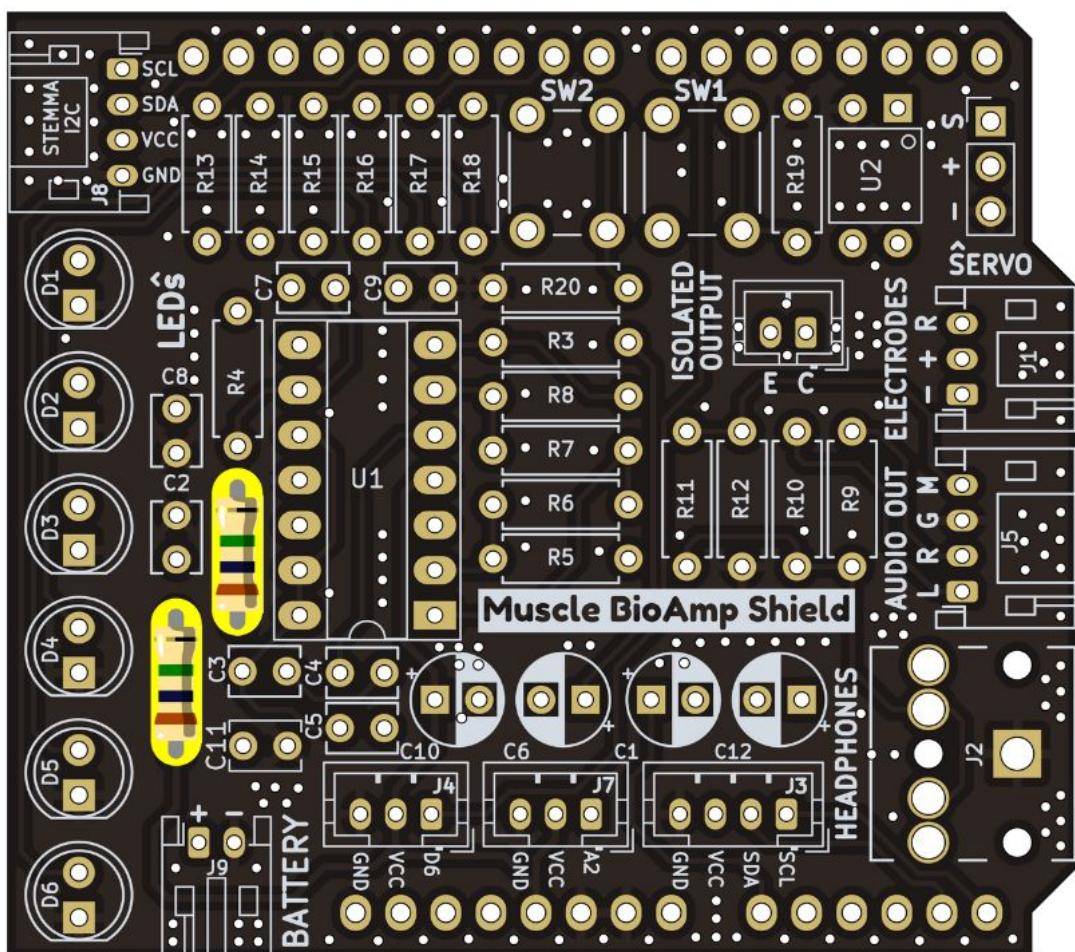


Fig. 2: Step 2 - 1M Resistors

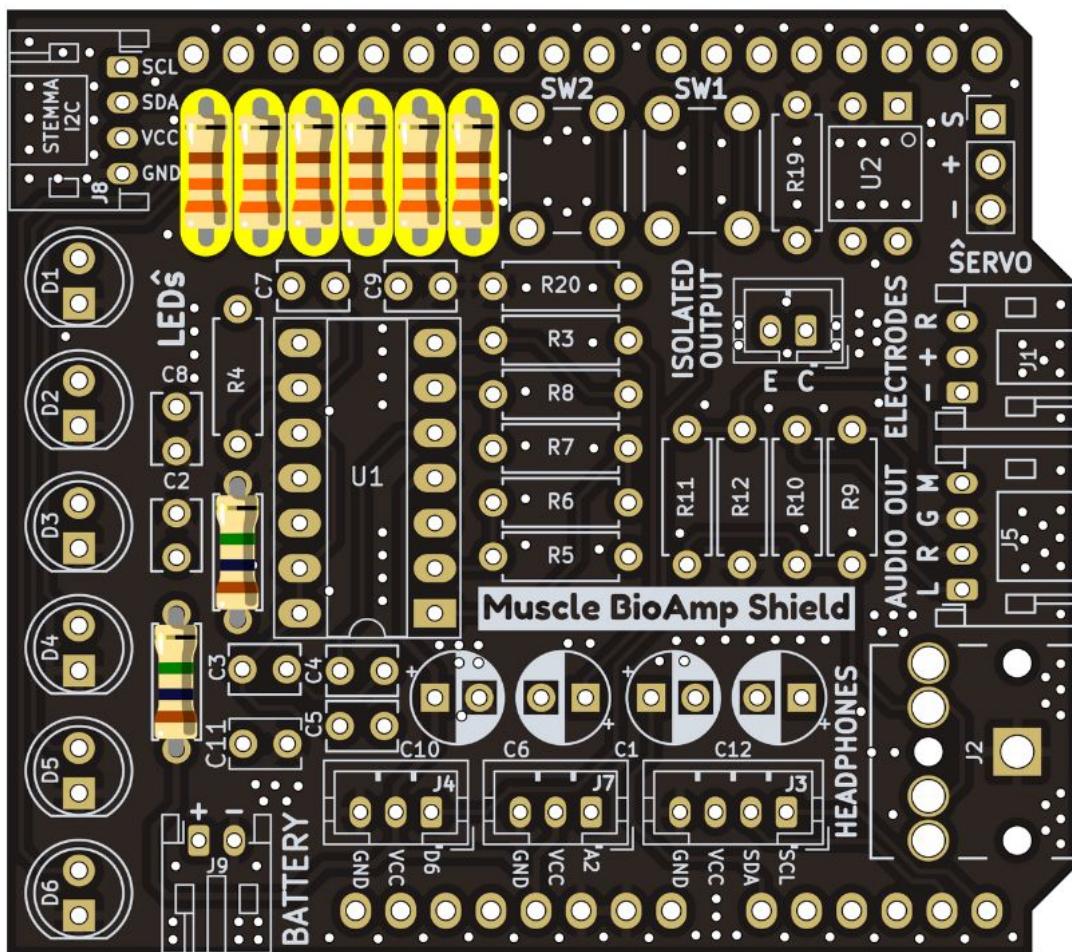


Fig. 3: Step 3 - 330R Resistors

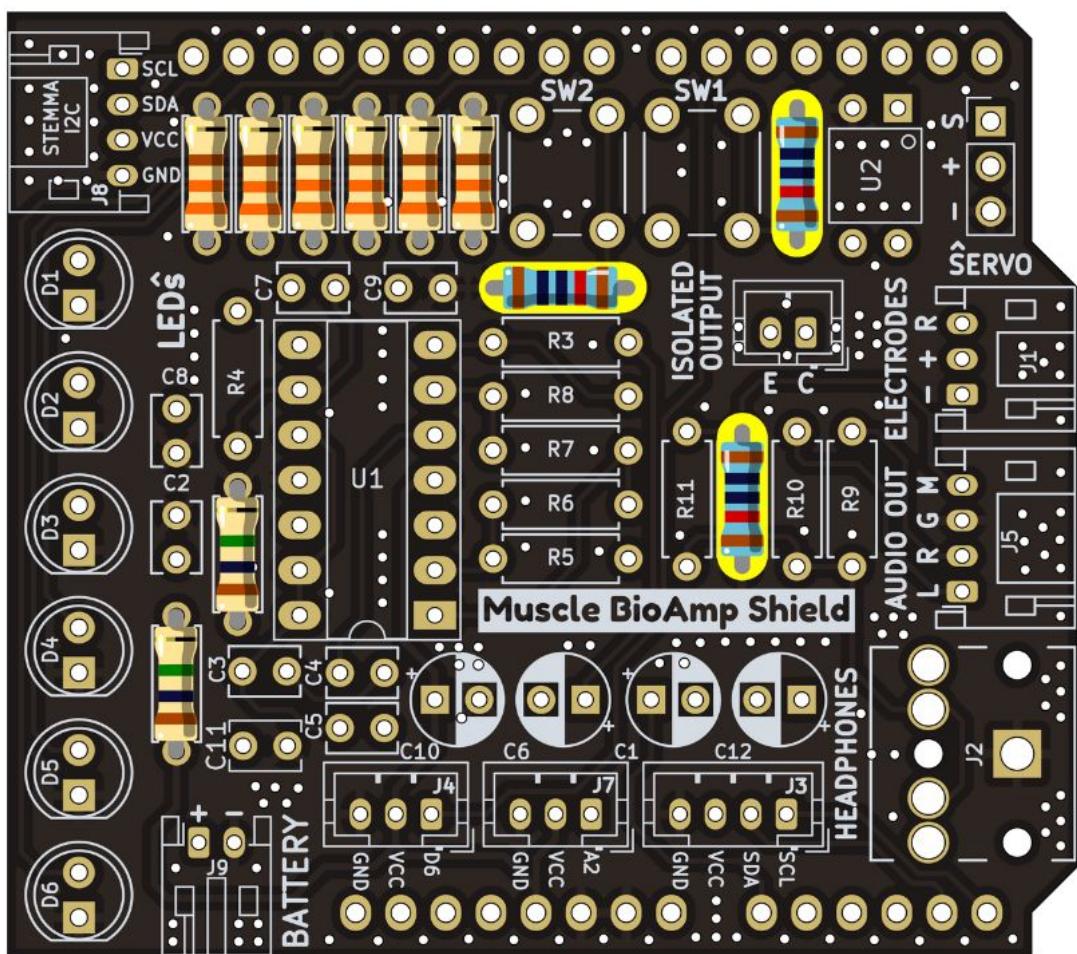


Fig. 4: Step 4 - 10K Resistors

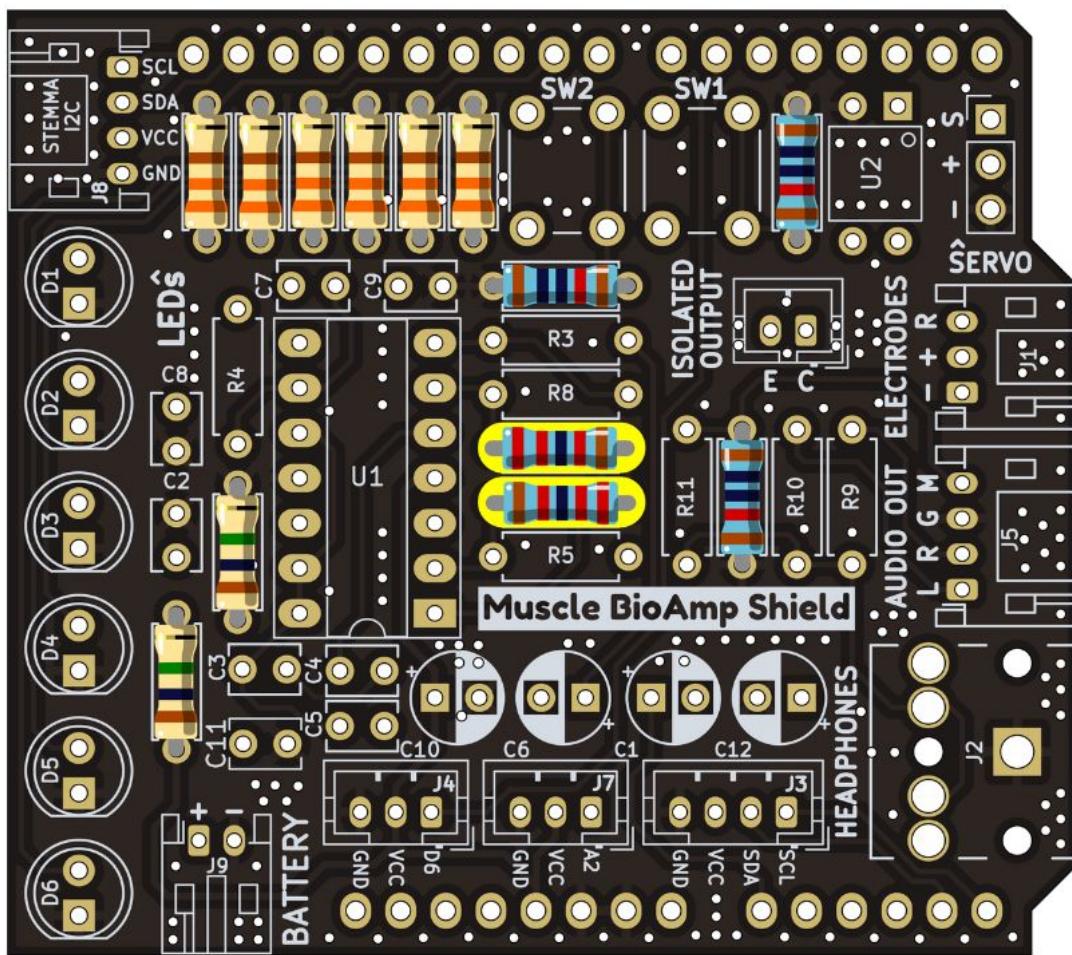


Fig. 5: Step 5 - 22K Resistors

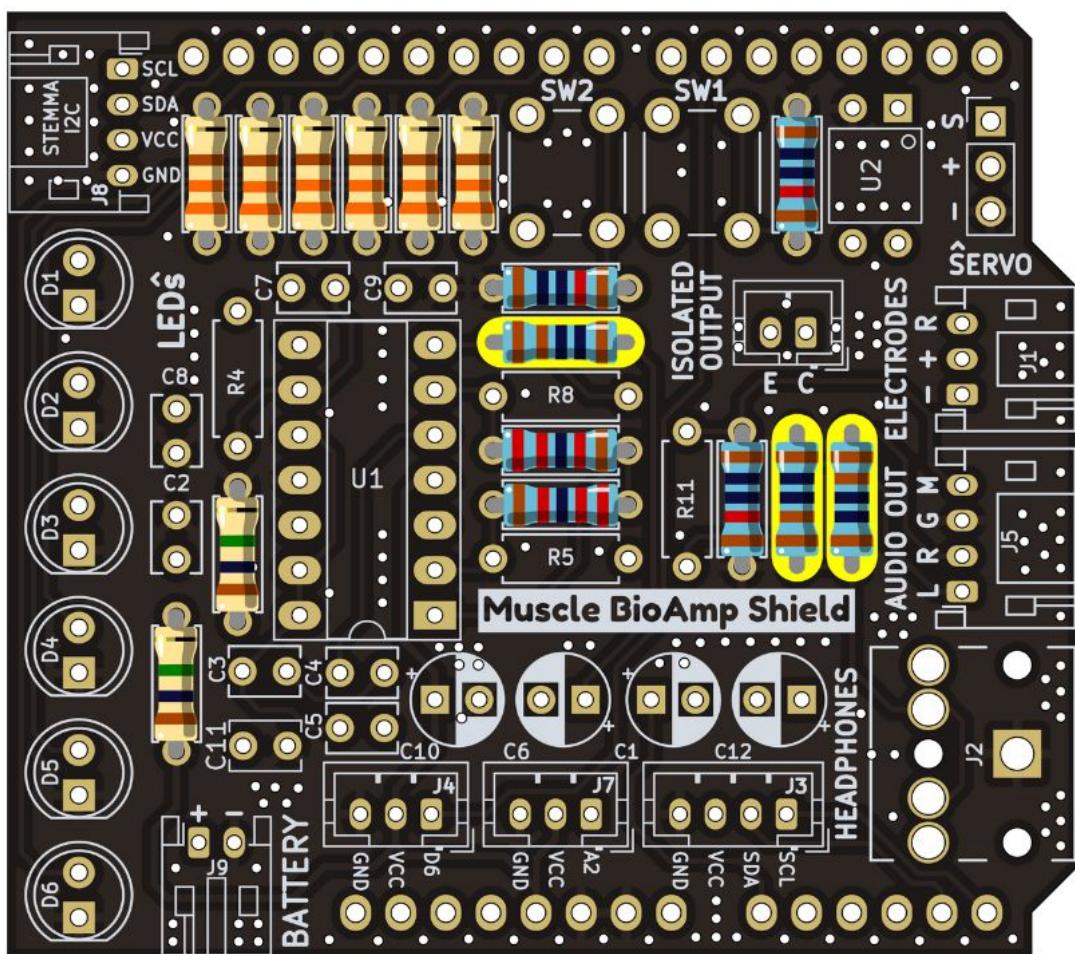


Fig. 6: Step 6 - 1K Resistors

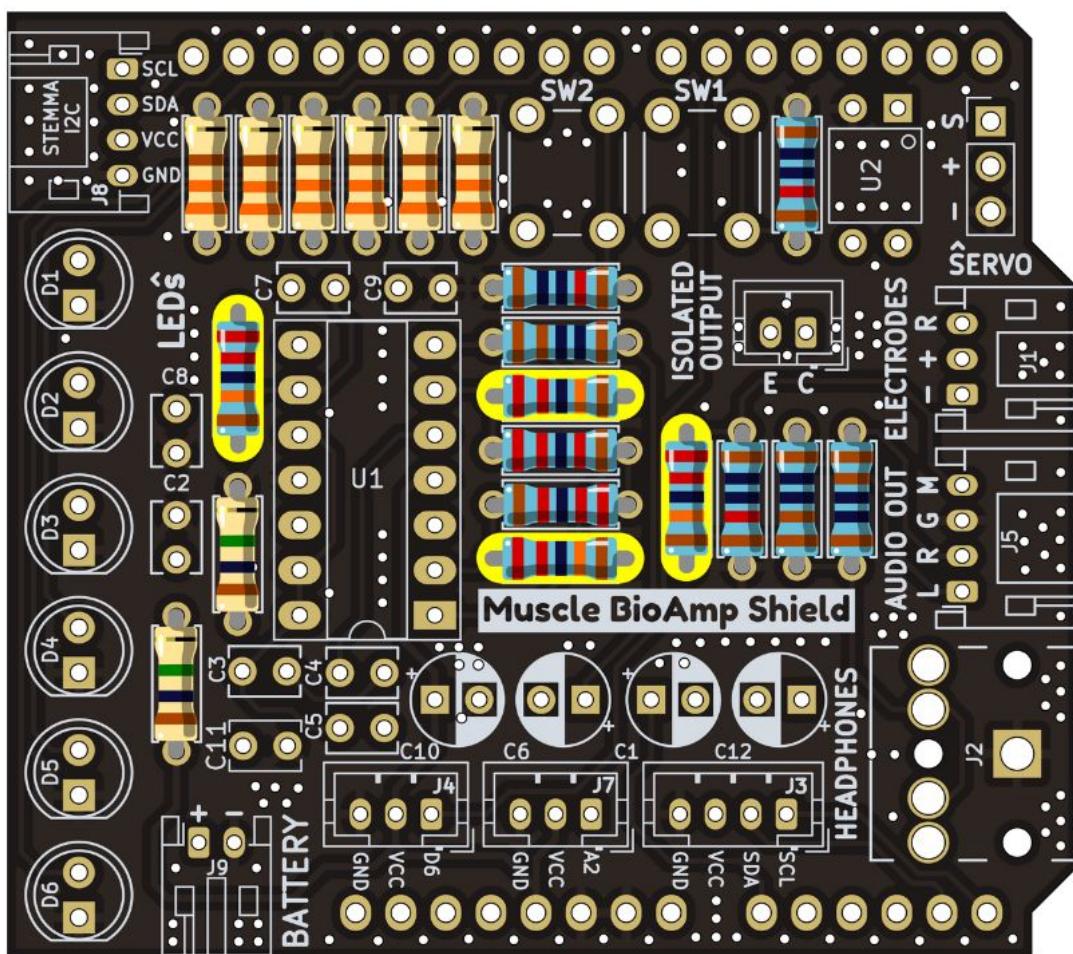


Fig. 7: Step 7 - 220K Resistors

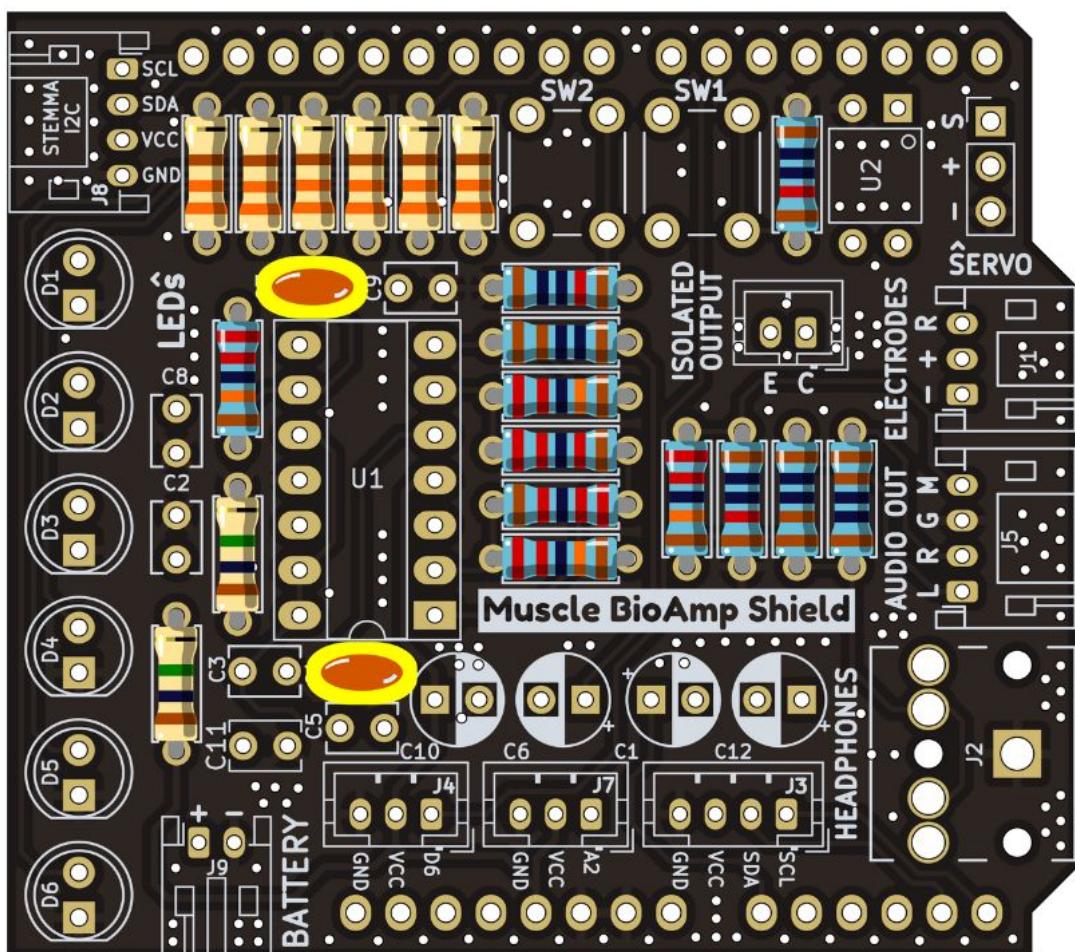


Fig. 8: Step 8 - 1nF Capacitors

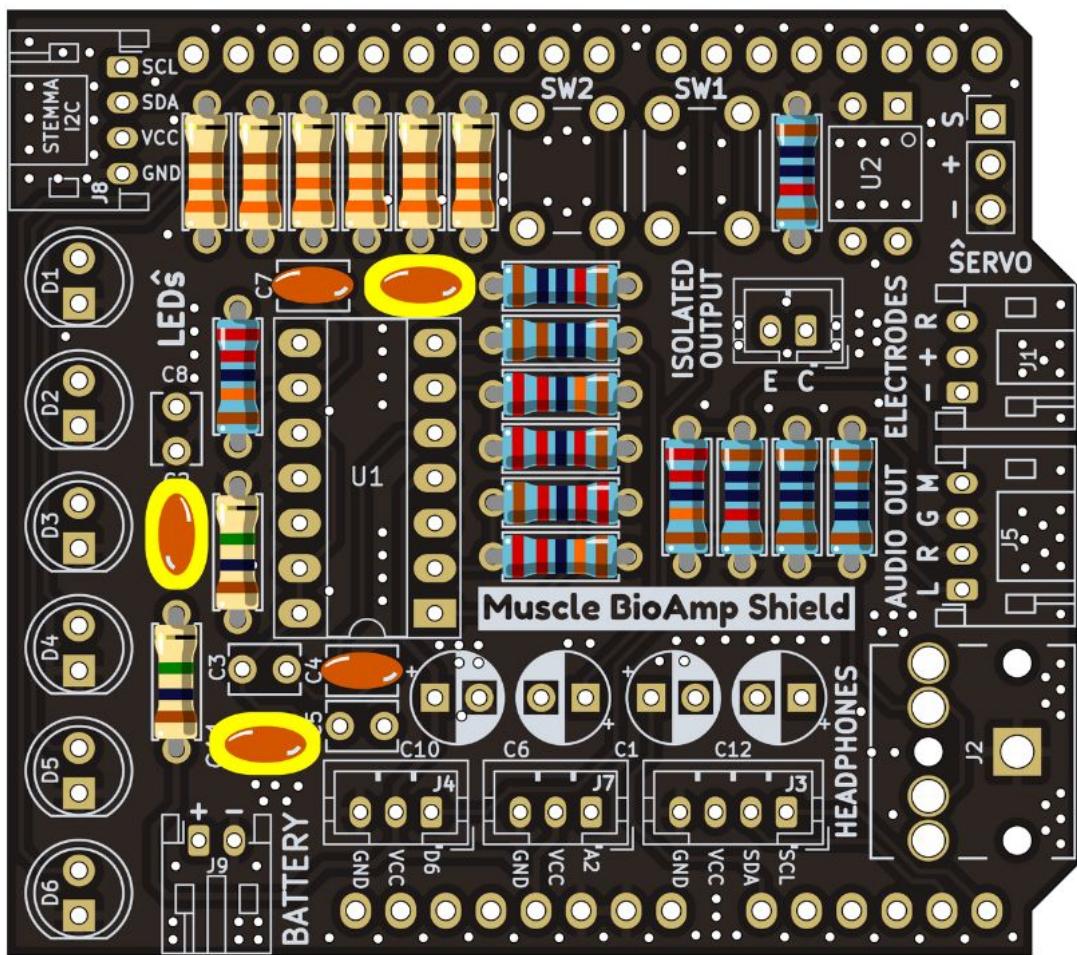


Fig. 9: Step 9 - 100nF Capacitors

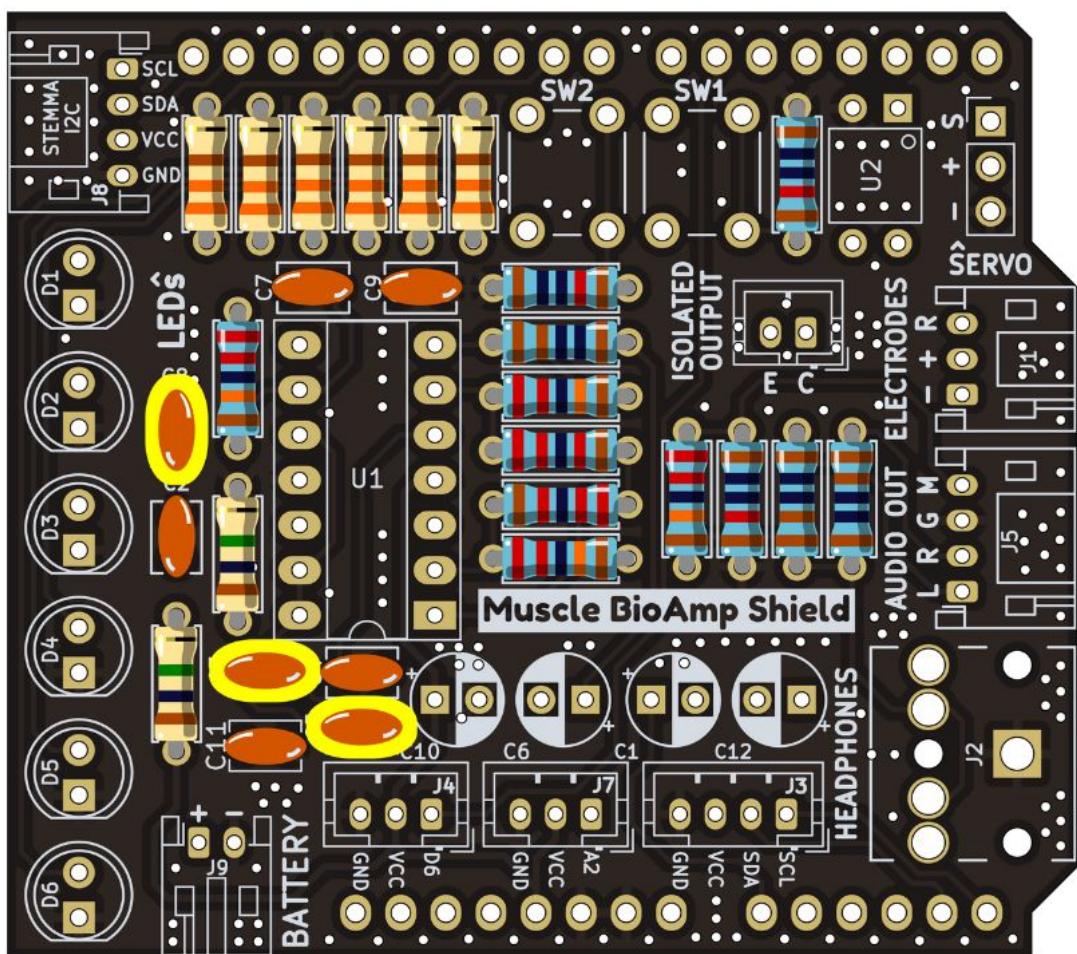


Fig. 10: Step 10 - 100pF Capacitors

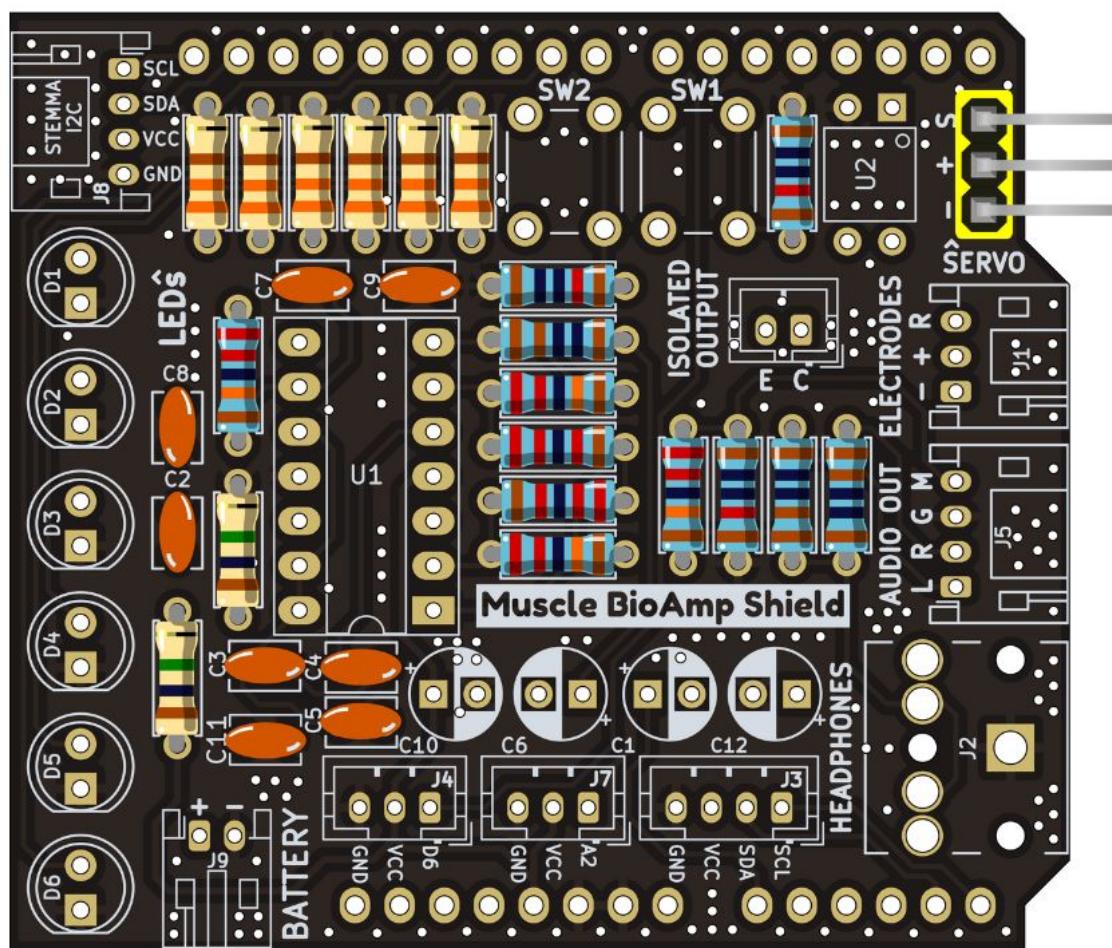


Fig. 11: Step 11 - Angled Header Pins

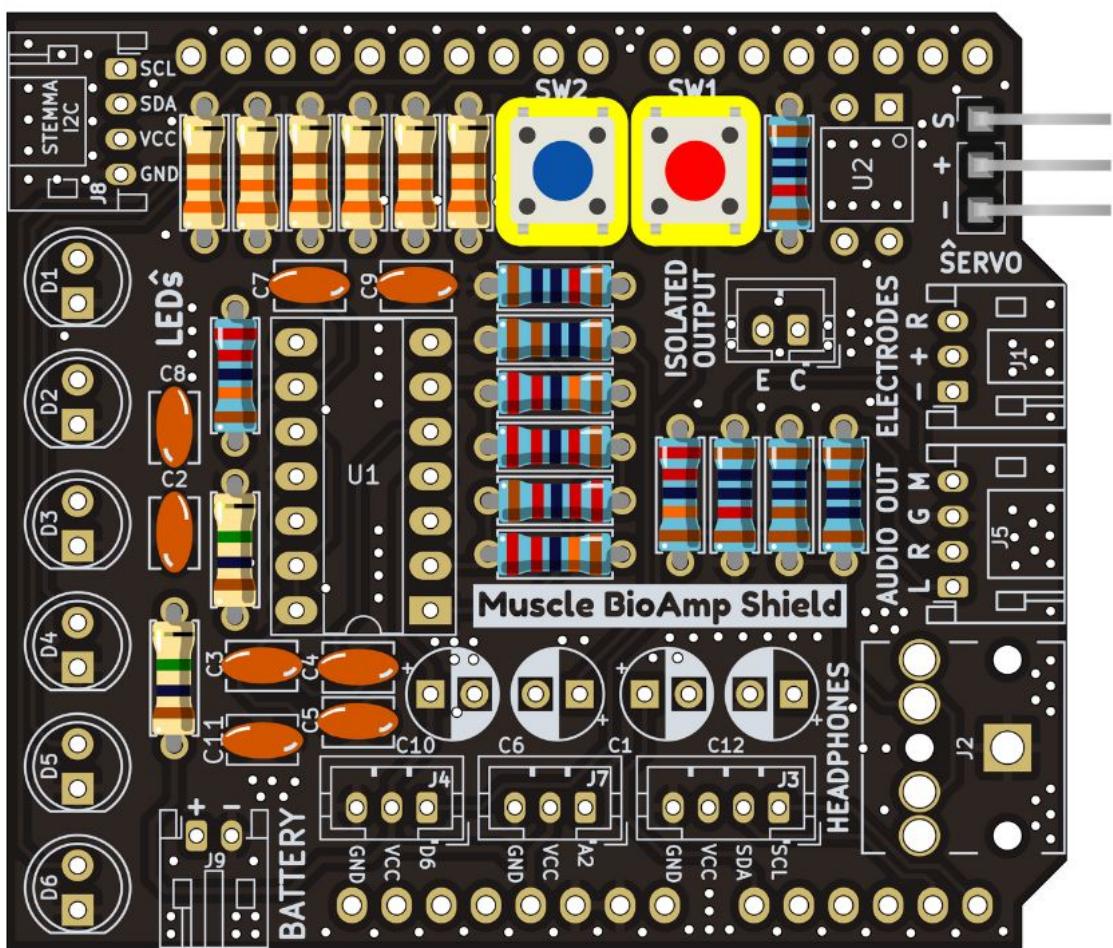


Fig. 12: Step 12 - 5x5mm Buttons

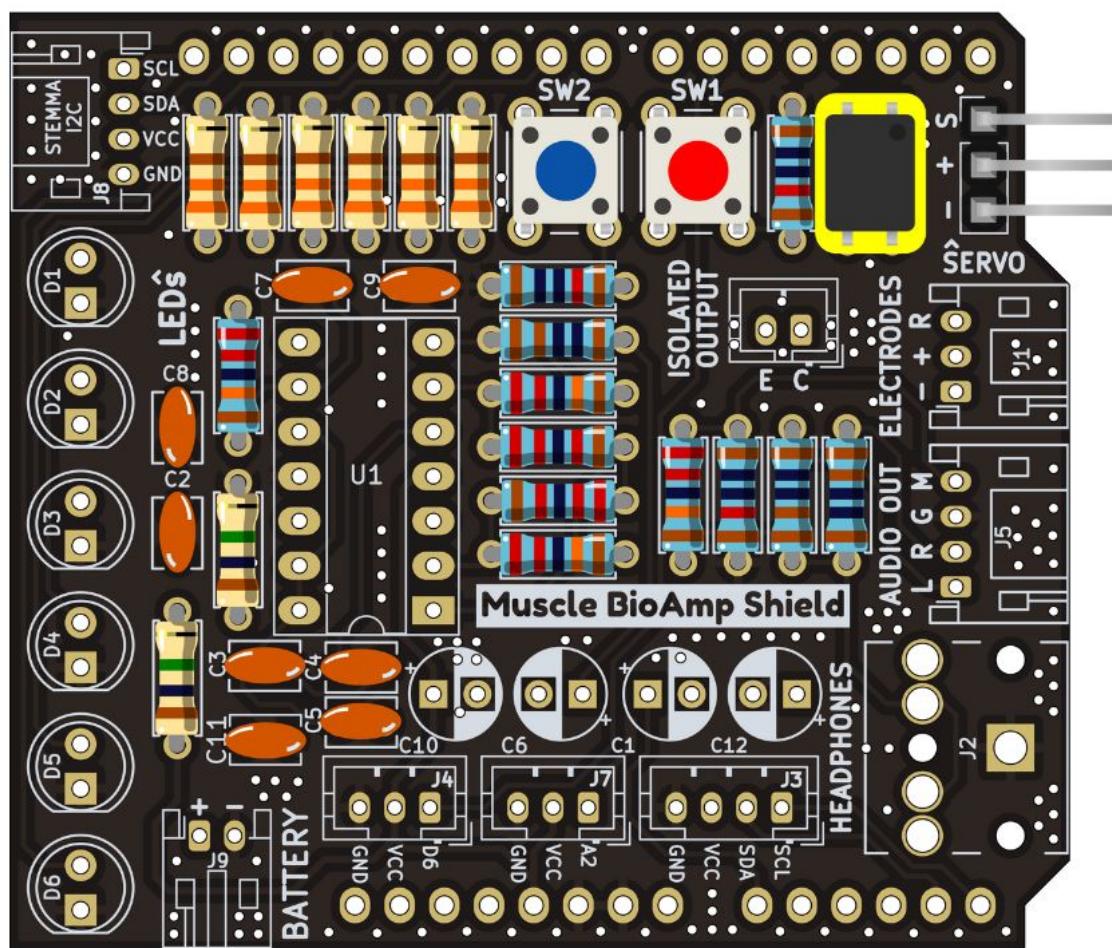


Fig. 13: Step 13 - OptoIsolator

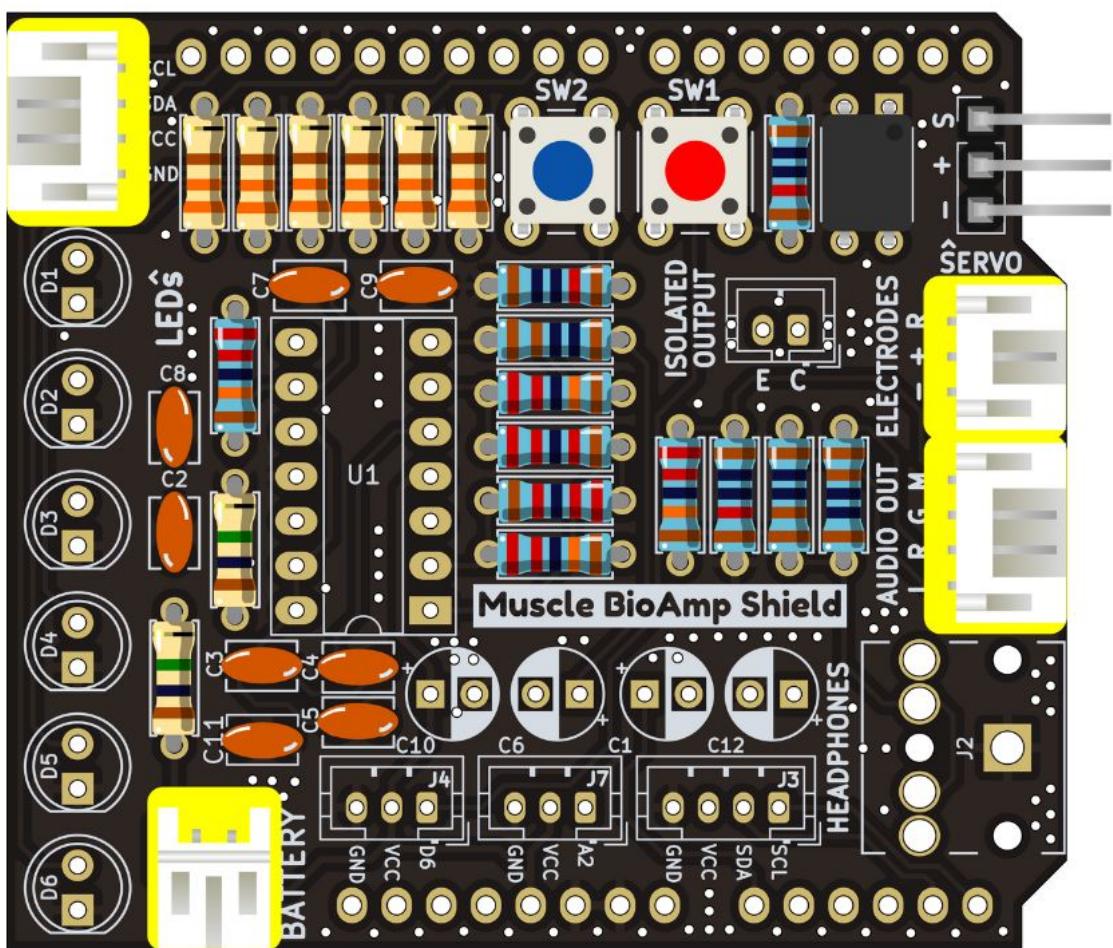


Fig. 14: Step 14 - JST PH Angled Connectors

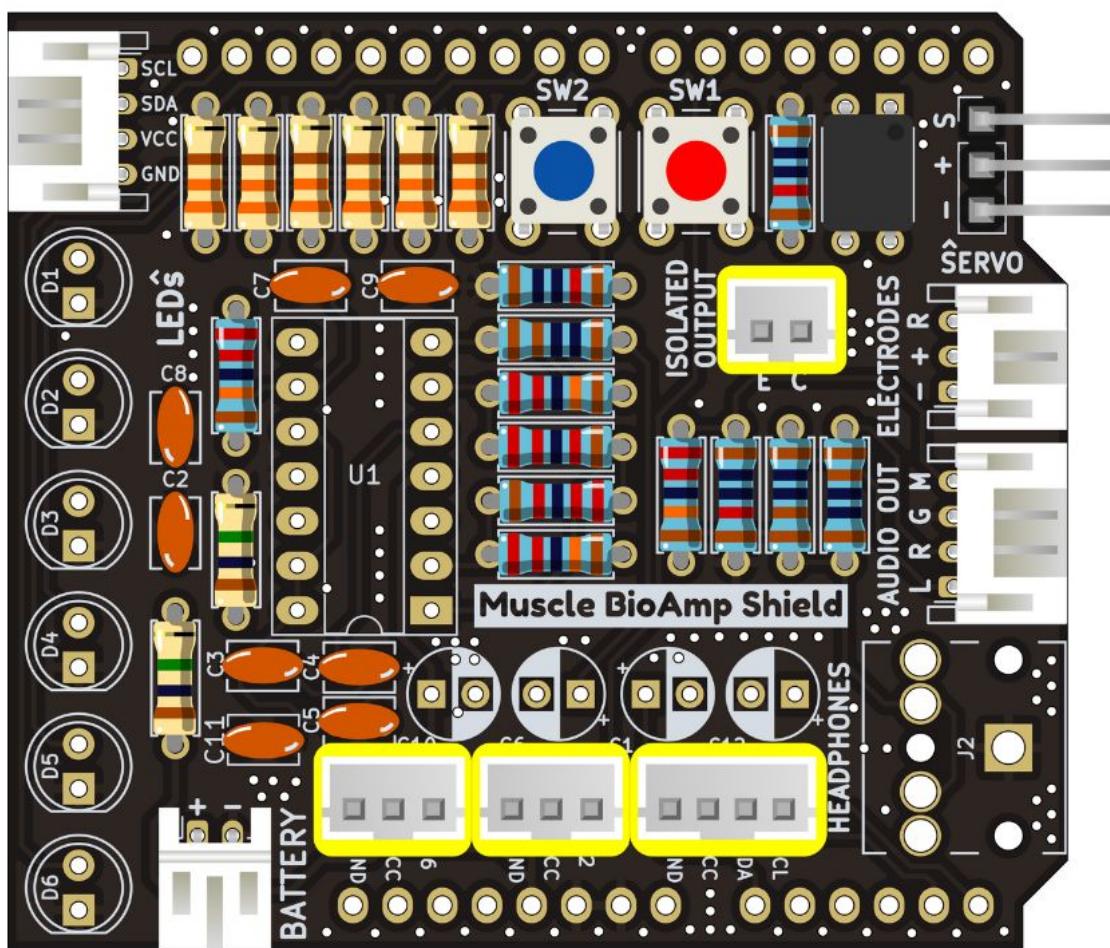


Fig. 15: Step 15 - JST PH Straight Connectors

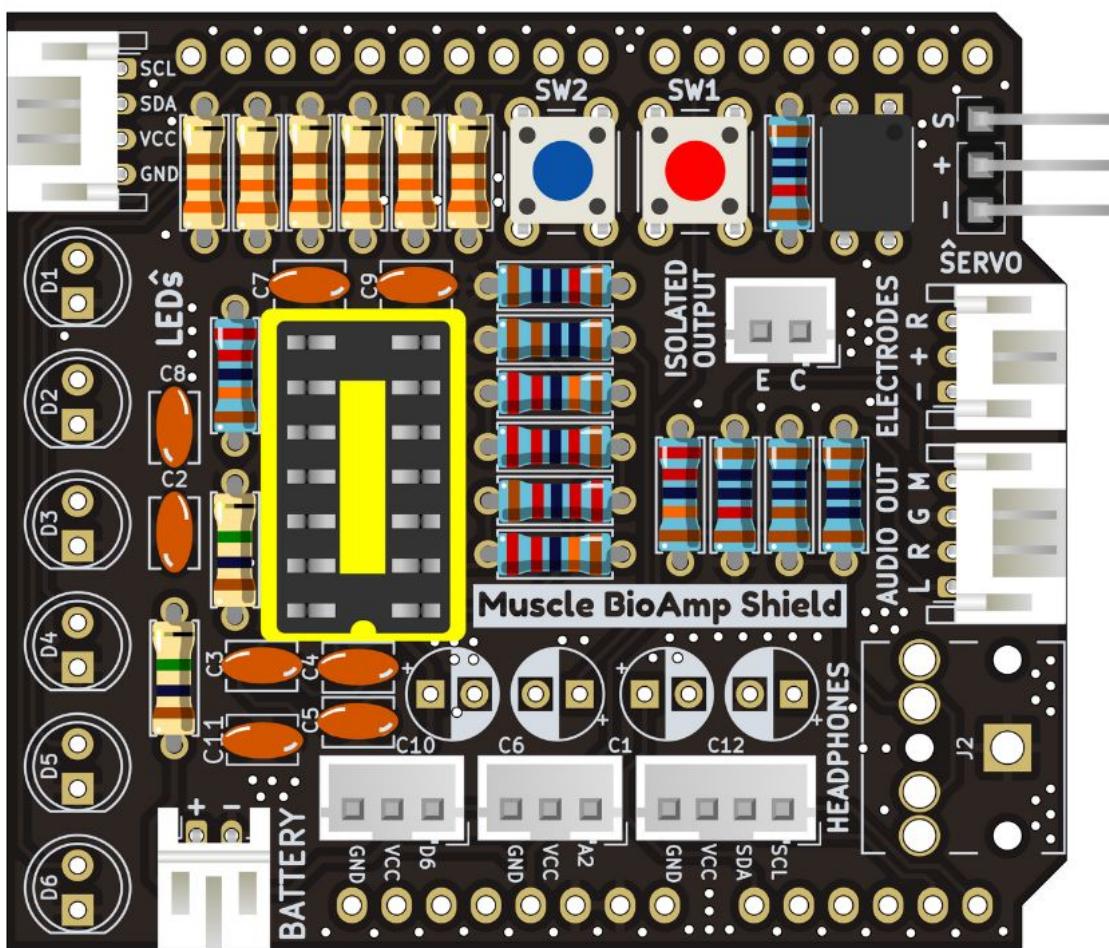


Fig. 16: Step 16 - IC Socket

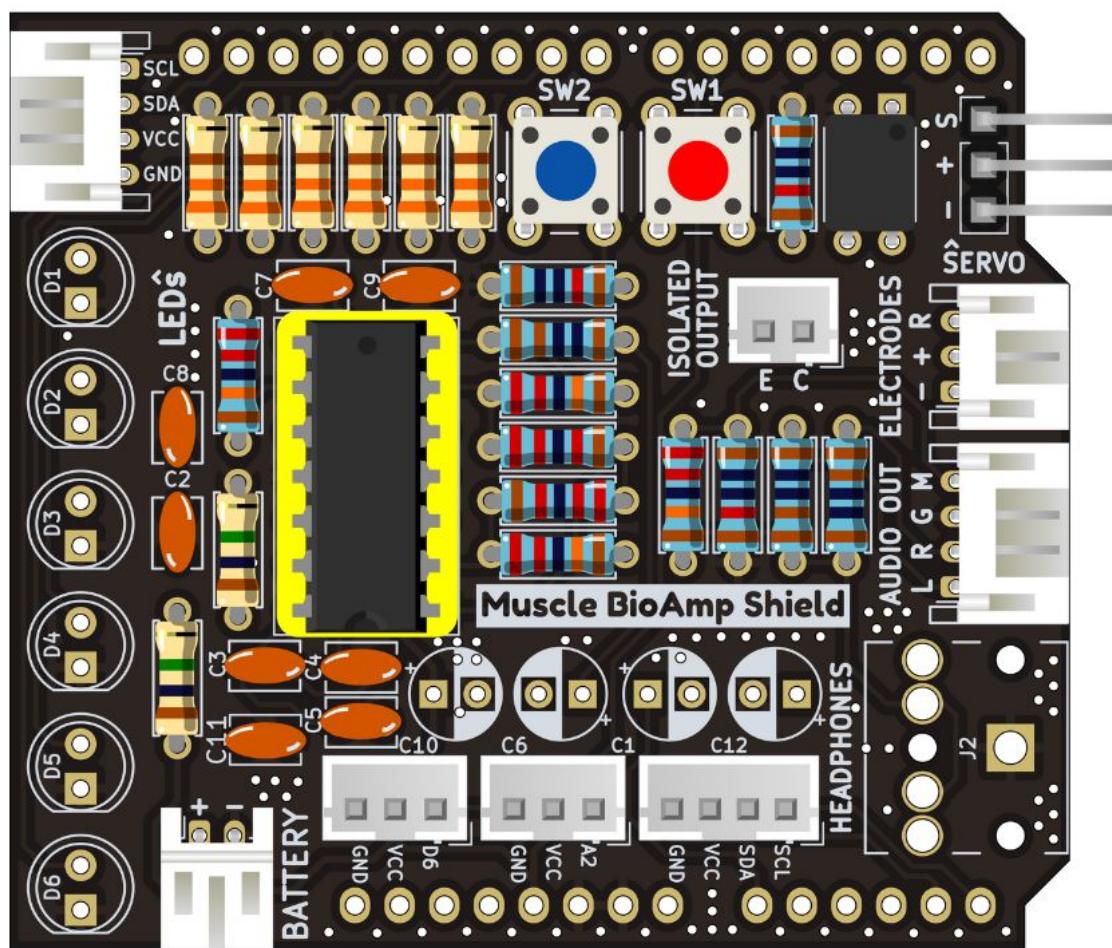


Fig. 17: Step 17 - IC

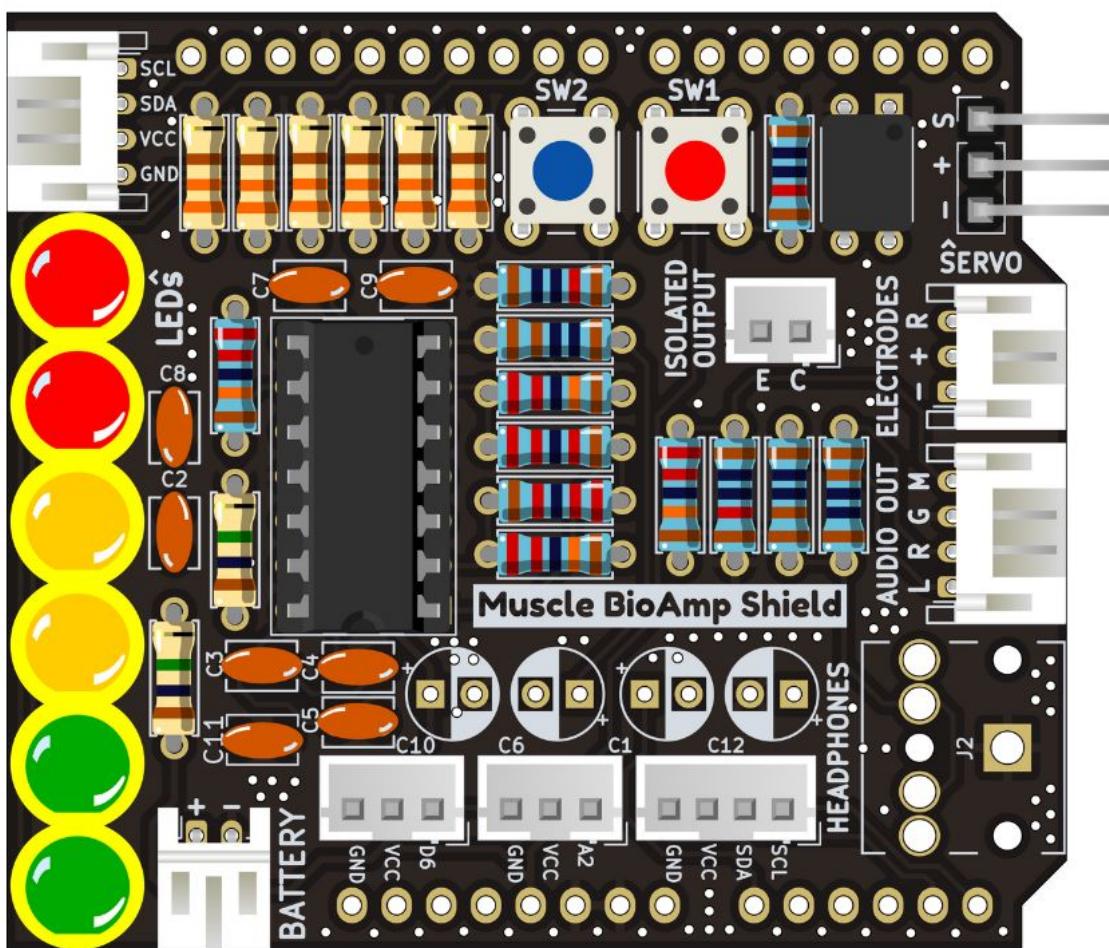


Fig. 18: Step 18 - LEDs

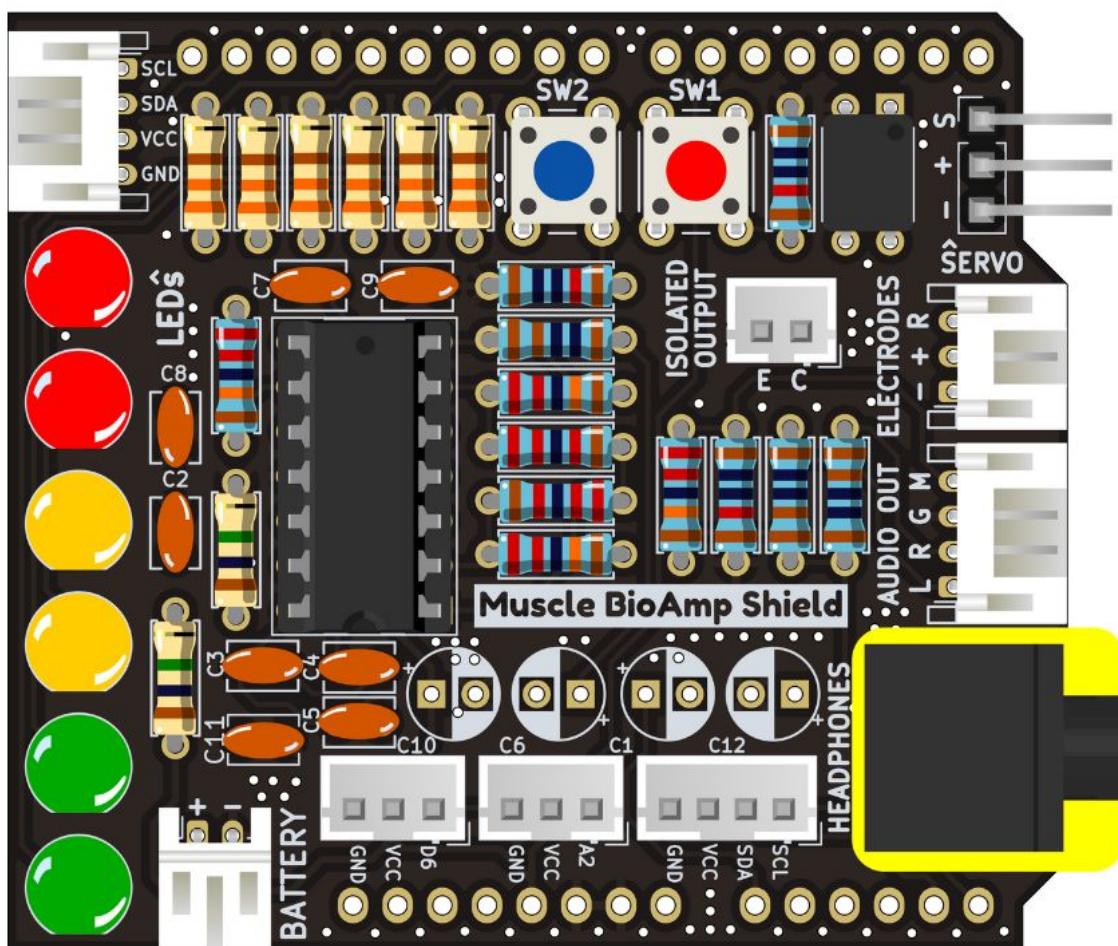


Fig. 19: Step 19 - 3.5mm Headphone Jack

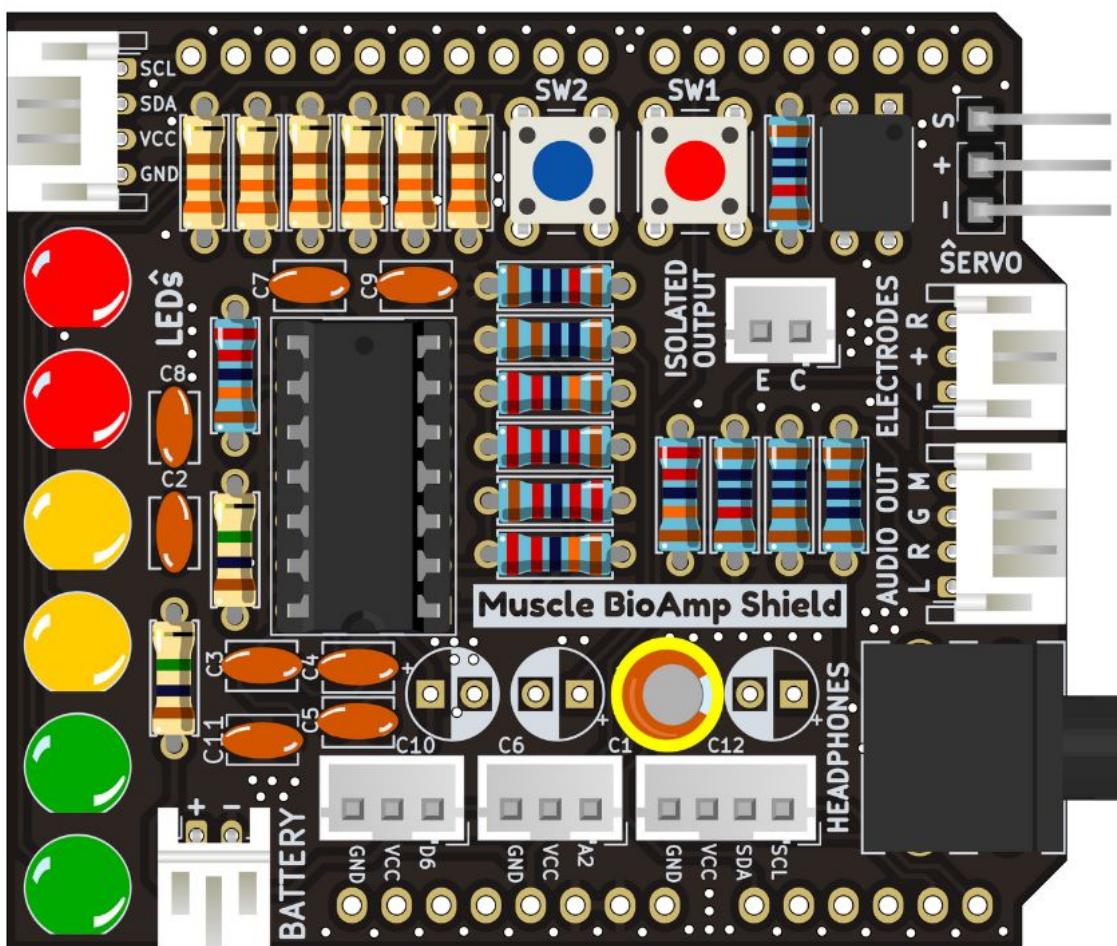


Fig. 20: Step 20 - 2.2uF Capacitor

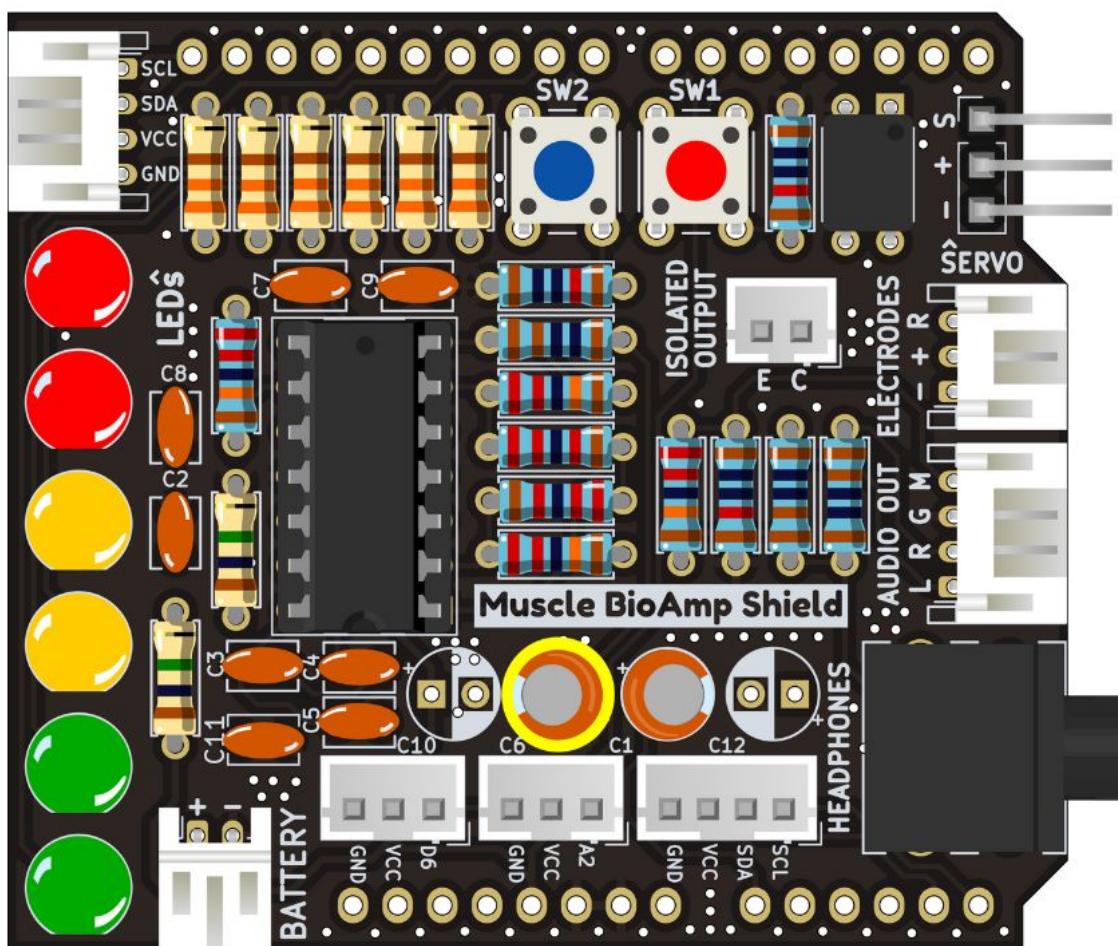


Fig. 21: Step 21 - 1uF Capacitor

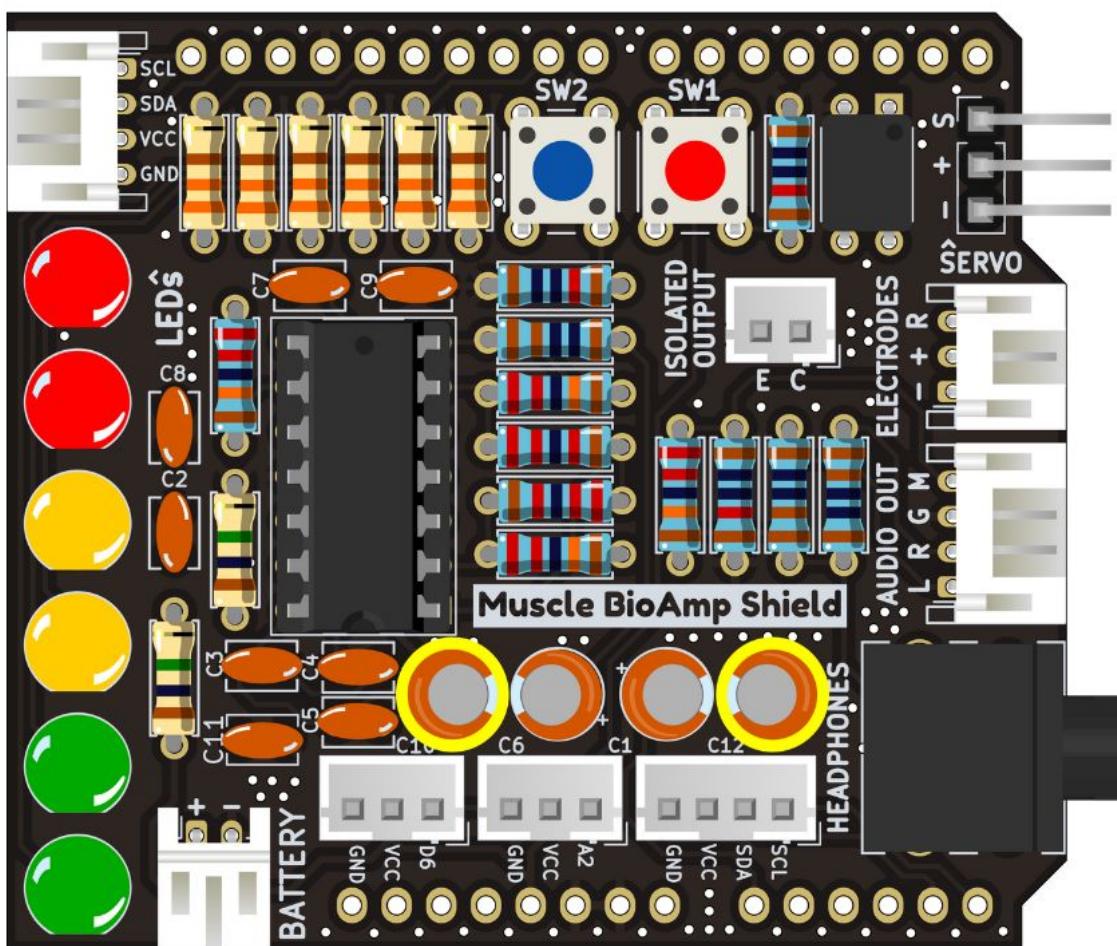


Fig. 22: Step 22 - 470uF Capacitor

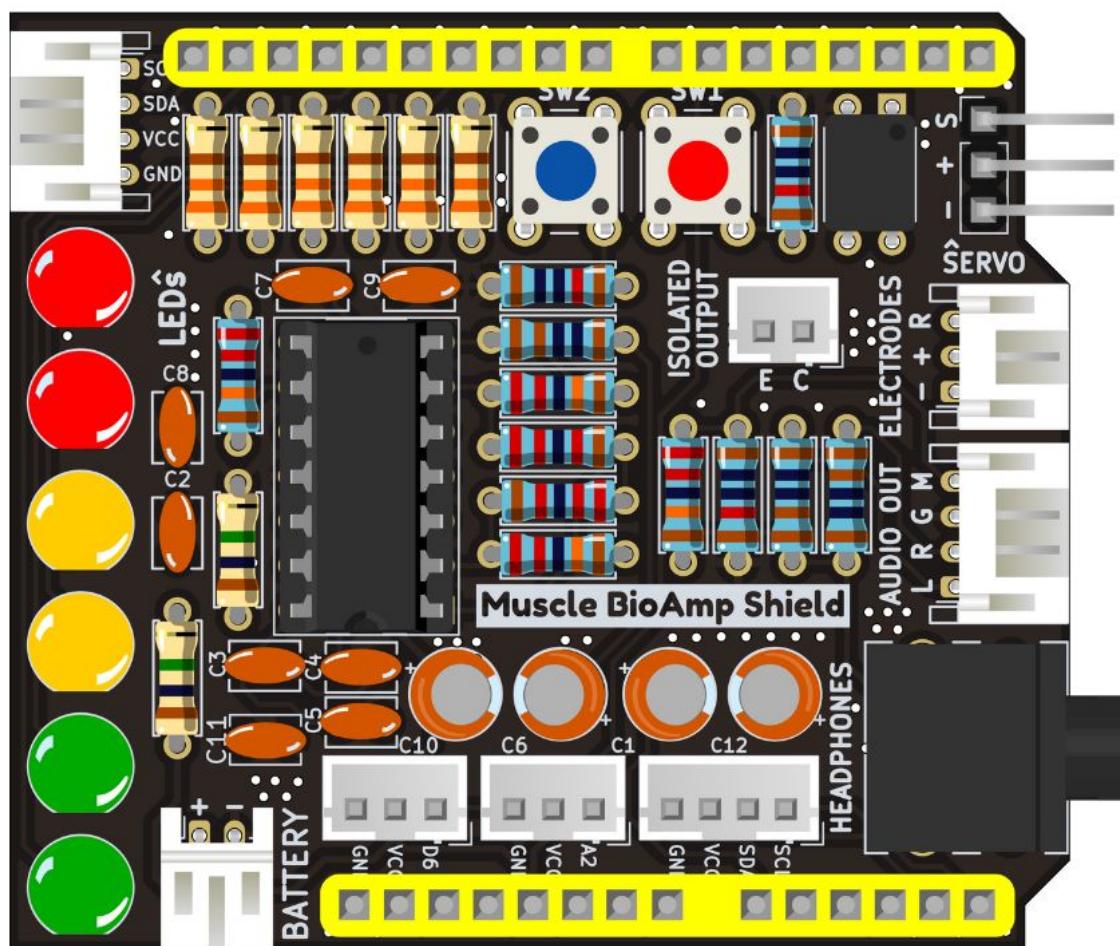


Fig. 23: Step 23 - Header Pins

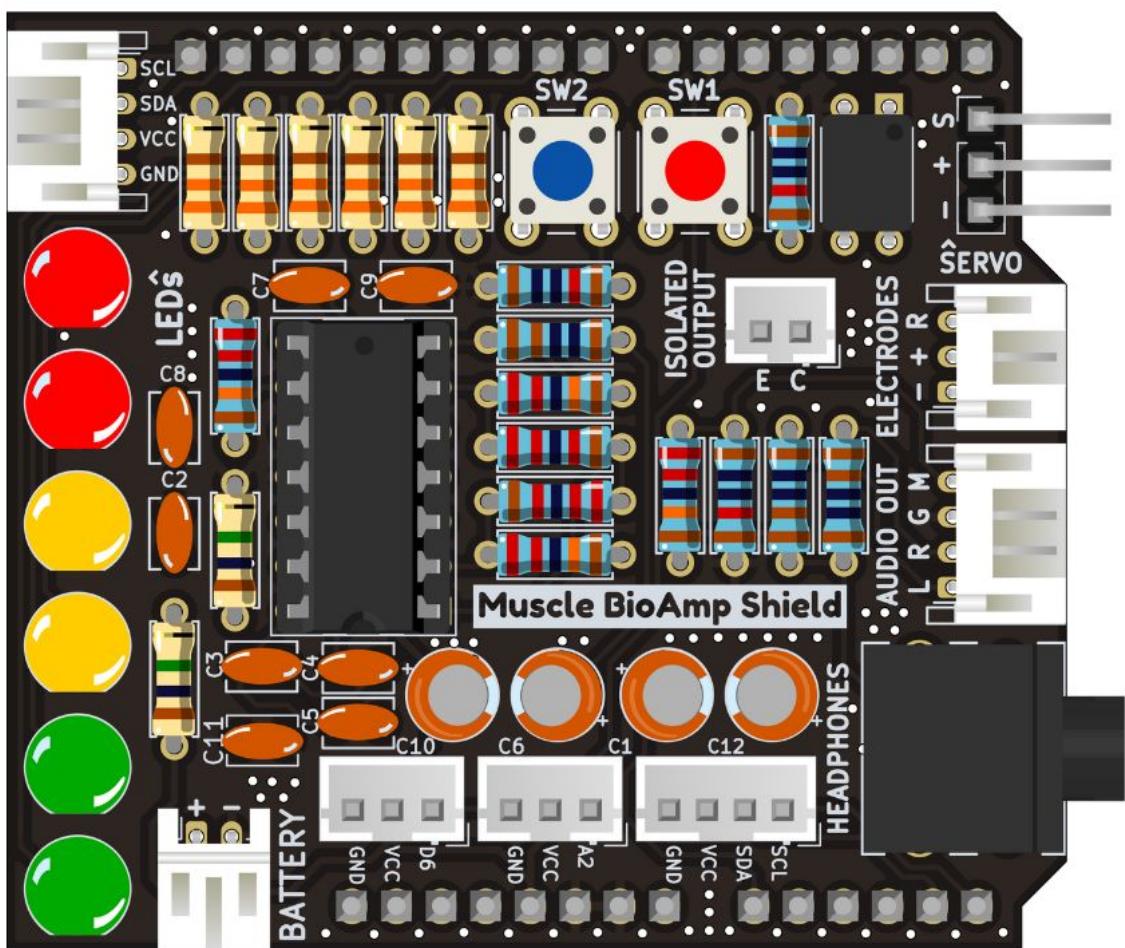
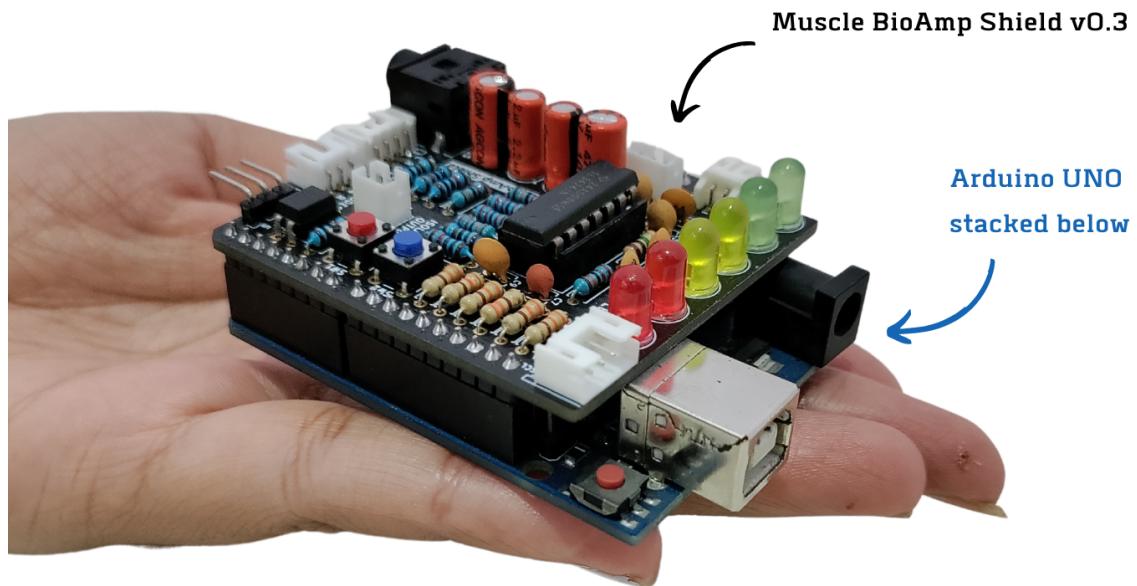


Fig. 24: Step 24 - Assembled Shield

## USING THE SENSOR

### 7.1 Step 1: Stack on Arduino Uno

Stack the Muscle BioAmp Shield on top of Arduino Uno properly.



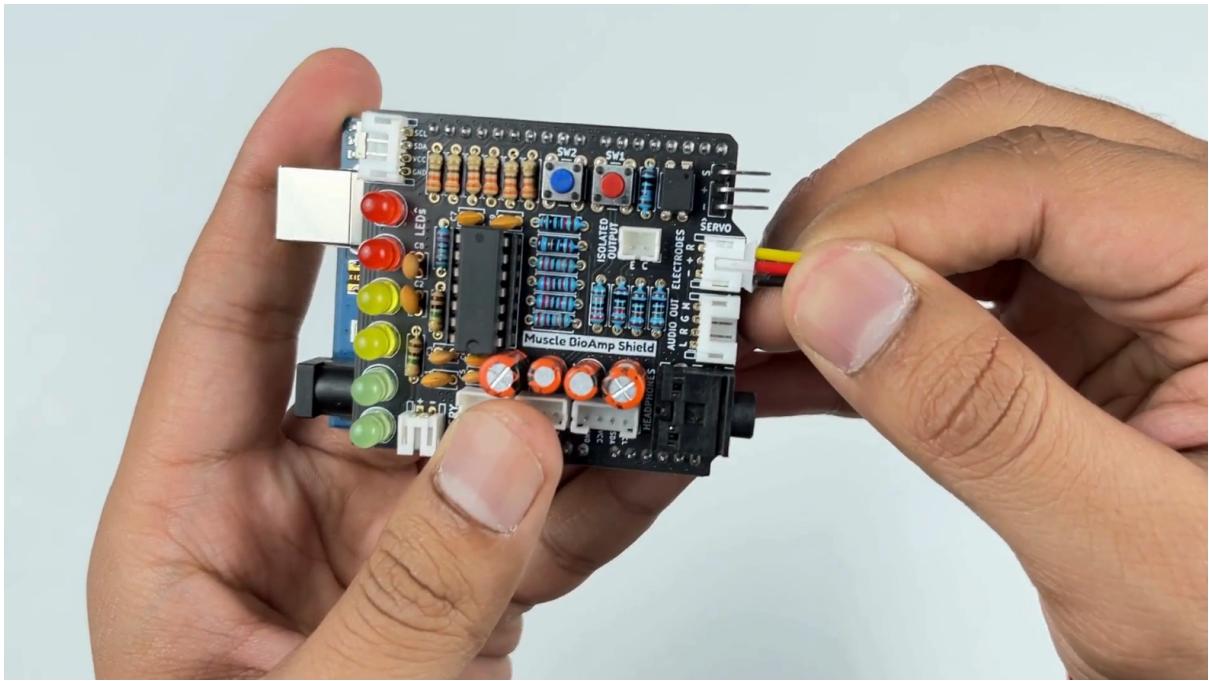
### 7.2 Step 2: Connecting Electrode Cable

Connect the BioAmp Cable to Muscle BioAmp Shield as shown.

### 7.3 Step 3: Skin Preparation

Apply Nuprep Skin Preparation Gel on the skin surface where electrodes would be placed to remove dead skin cells and clean the skin from dirt. After rubbing the skin surface thoroughly, clean it with an alcohol wipe or a wet wipe.

For more information, please check out detailed step by step skin-preparation.



## 7.4 Step 4: Electrode Placements

We have 2 options to measure the EMG signals, either using the gel electrodes or using dry electrode based Muscle BioAmp Band. You can try both of them one by one.

### 7.4.1 Using gel electrodes

1. Connect the BioAmp cable to gel electrodes,
2. Peel the plastic backing from electrodes
3. Place the IN+ and IN- cables on the arm near the ulnar nerve & REF (reference) at the back of your hand as shown in the connection diagram.

### 7.4.2 Using Muscle BioAmp Band

1. Connect the BioAmp cable to Muscle BioAmp Band in a way such that IN+ and IN- are placed on the arm near the ulnar nerve & REF (reference) on the far side of the band.
2. Now put a small drop of electrode gel between the skin and metallic part of BioAmp cable to get the best results.

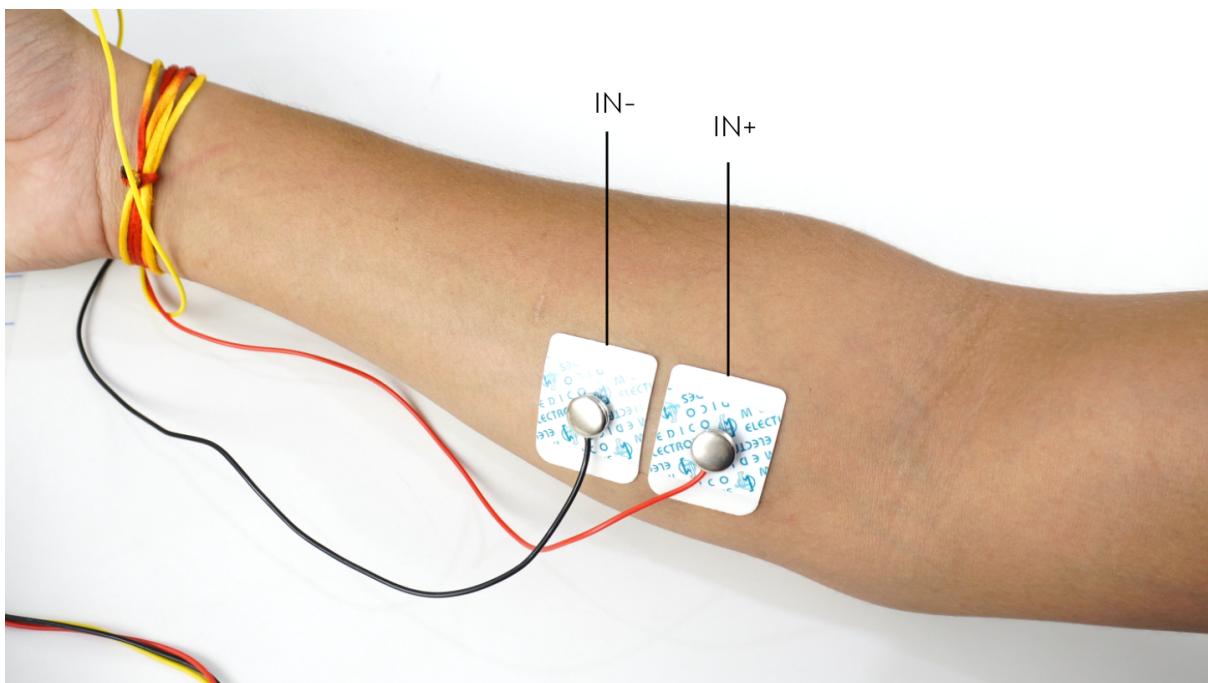
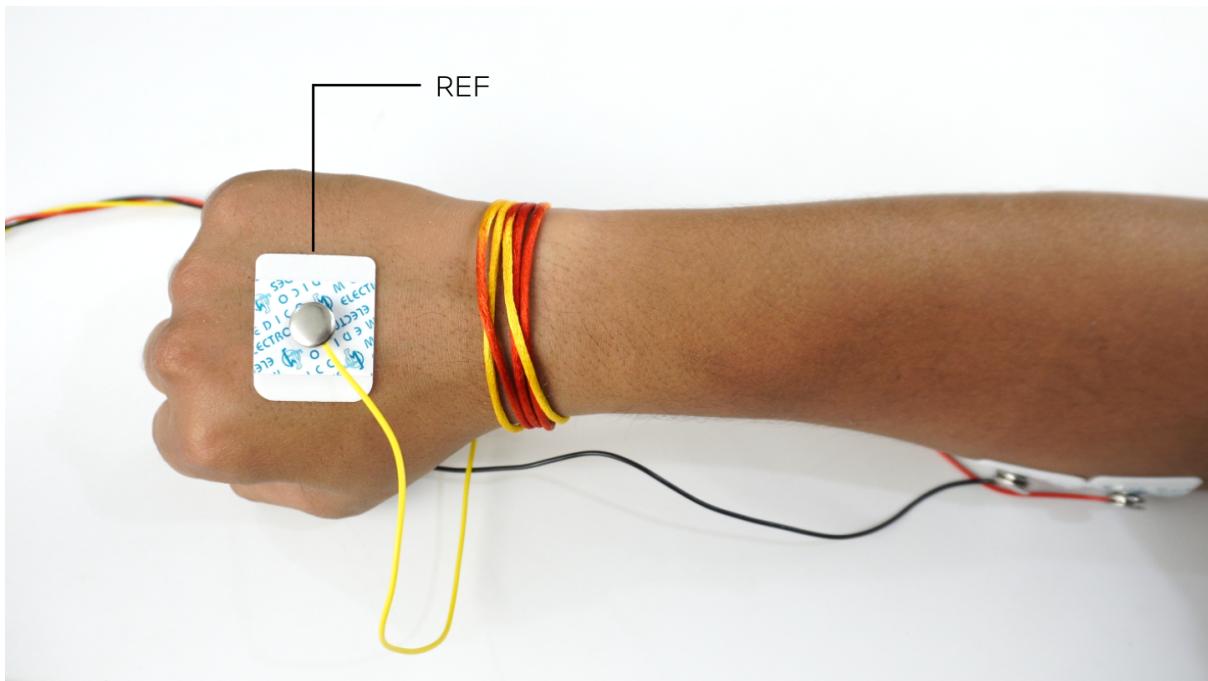
**Tutorial on how to use the band:**

<https://youtu.be/xYZdw0aes0>

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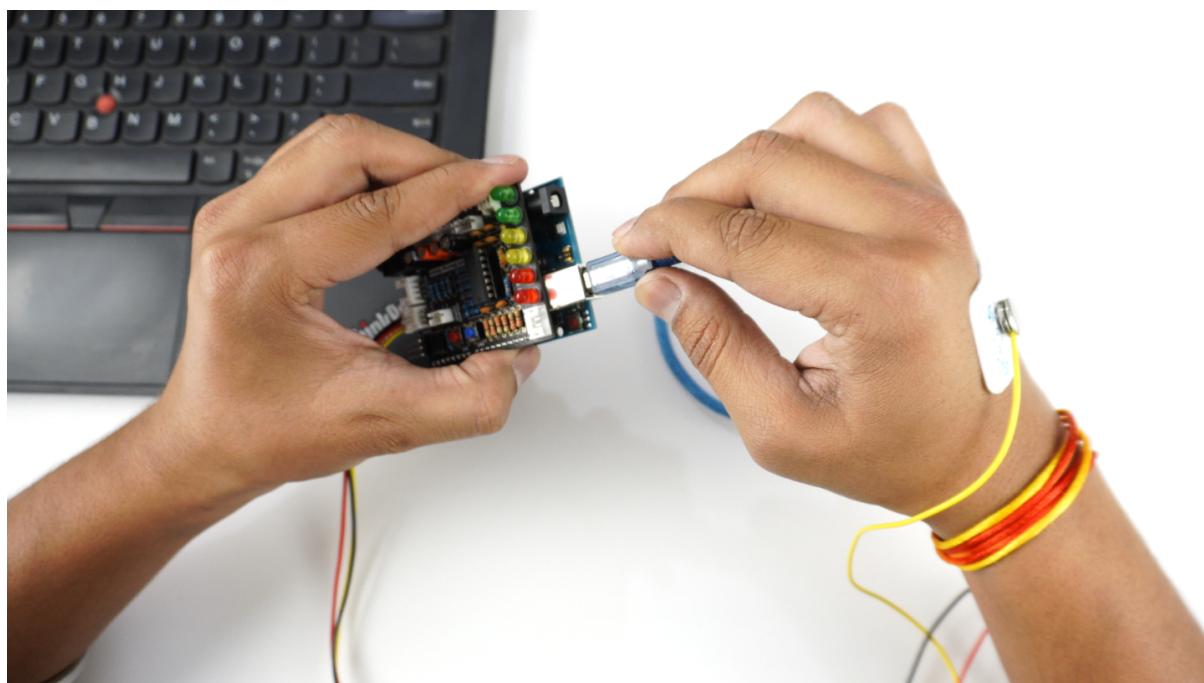
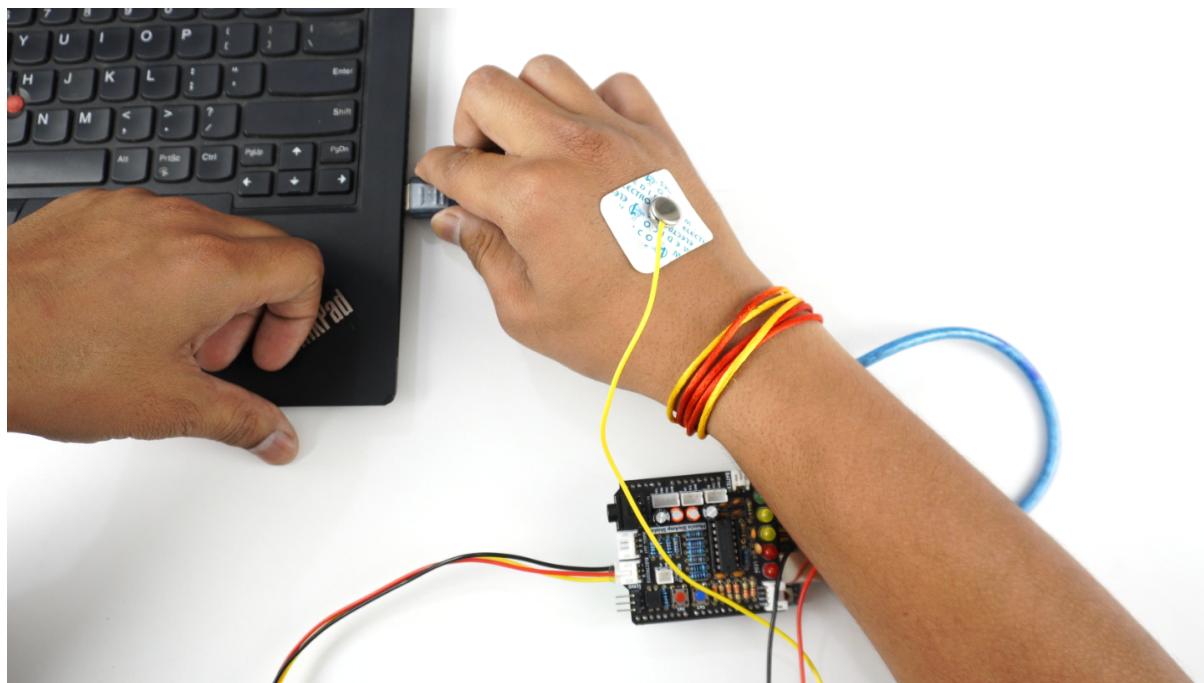
**Note:** In this demonstration we are recording EMG signals from the ulnar nerve, but you can record EMG from other areas as well (biceps, triceps, legs, jaw etc) as per your project requirements. Just make sure to place the IN+, IN- electrodes on the targeted muscle and REF on a bony part.

---



## 7.5 Step 5: Connect Arduino UNO to your laptop

Connect your Arduino UNO R3 to your laptop using the USB cable (Type A to Type B).



**Warning:** Make sure your laptop is not connected to a charger and sit 5m away from any AC appliances for best signal acquisition.

## 7.6 Step 6: Visualise EMG signals on laptop

Copy paste any one of the arduino sketches given below in Arduino IDE v1.8.19 that you downloaded earlier:

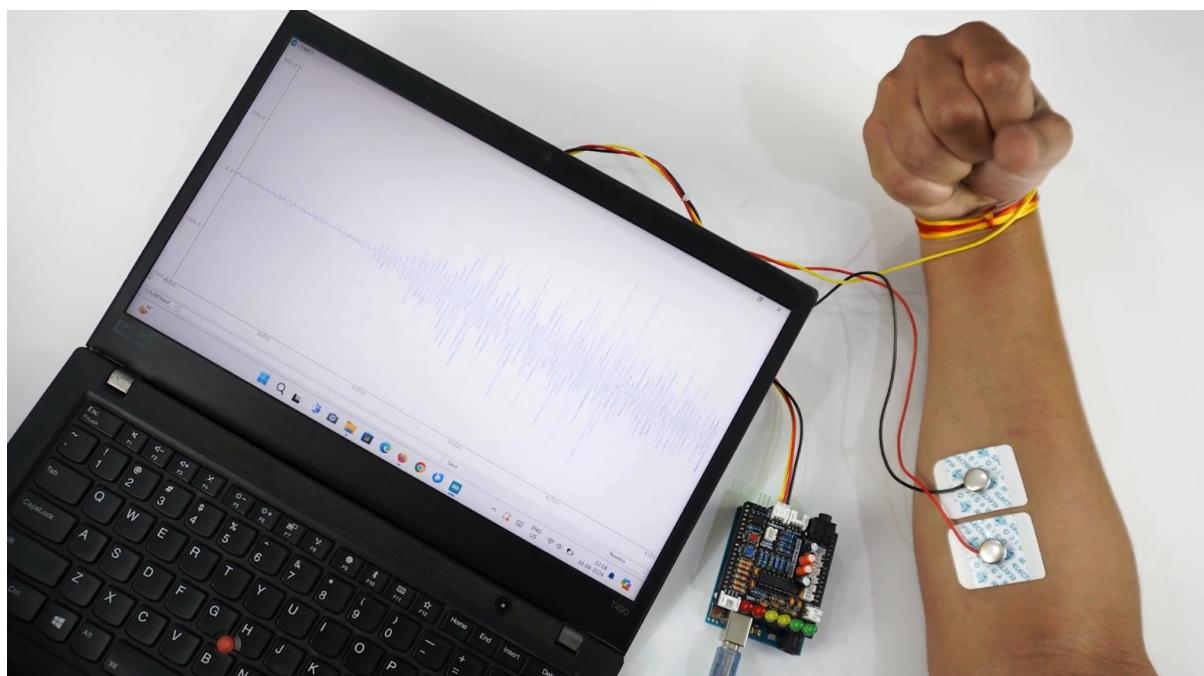
EMG Filter: [https://github.com/upsidedownlabs/Muscle-BioAmp-Arduino-Firmware/blob/main/2\\_EMGFilter/2\\_EMGFilter.ino](https://github.com/upsidedownlabs/Muscle-BioAmp-Arduino-Firmware/blob/main/2_EMGFilter/2_EMGFilter.ino)

EMG Envelope: [https://github.com/upsidedownlabs/Muscle-BioAmp-Arduino-Firmware/blob/main/3\\_EMGEnvelope/3\\_EMGEnvelope.ino](https://github.com/upsidedownlabs/Muscle-BioAmp-Arduino-Firmware/blob/main/3_EMGEnvelope/3_EMGEnvelope.ino)

Go to tools from the menu bar, select board option then select Arduino UNO. In the same menu, select the COM port on which your Arduino Uno is connected. To find out the right COM port, disconnect your board and reopen the menu. The entry that disappears should be the right COM port. Now upload the code, & open the serial plotter from the tools menu to visualize the EMG signals.

After opening the serial plotter make sure to select the baud rate to 115200.

Now flex your arm to visualize the muscle signals in real time on your laptop.

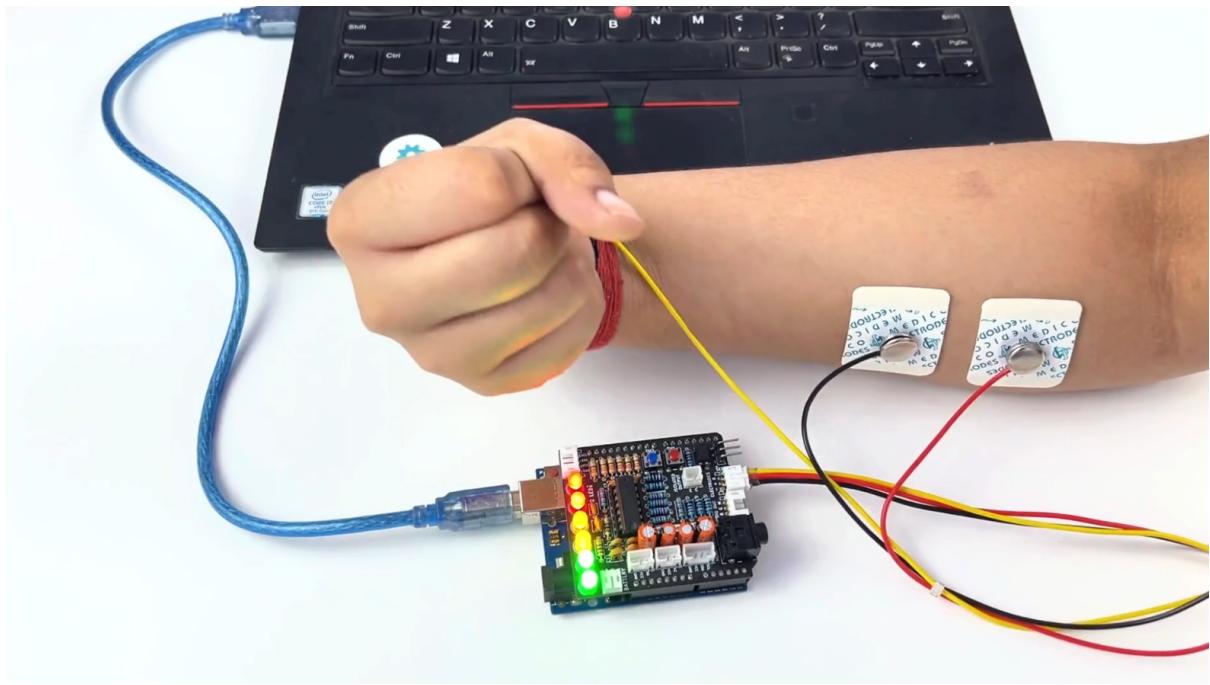


## 7.7 Step 7: Visualise EMG signals on LEDs

Copy paste the Arduino Sketch given below in Arduino IDE:

LED Bar Graph: <https://github.com/upsidedownlabs/BioAmp-EXG-Pill/blob/main/software/LEDBarGraph/LEDBarGraph.ino>

Make sure you have selected the right board and COM port. Now upload the code, and flex your arm. You'll see the LED bar going up. More strength you apply, more the LED bar goes up.

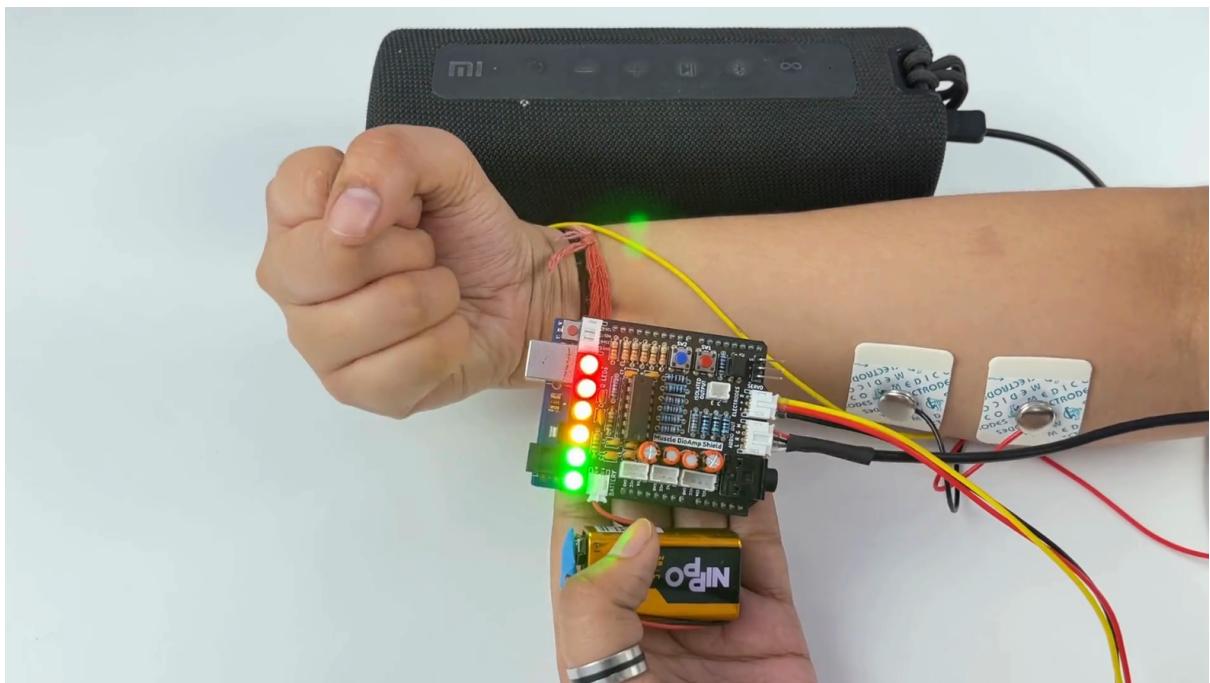


## 7.8 Step 8: Listen to your EMG signals

You can either listen to the muscle signals (EMG) on a speaker or wired earphones/headphones. Let's try both of them.

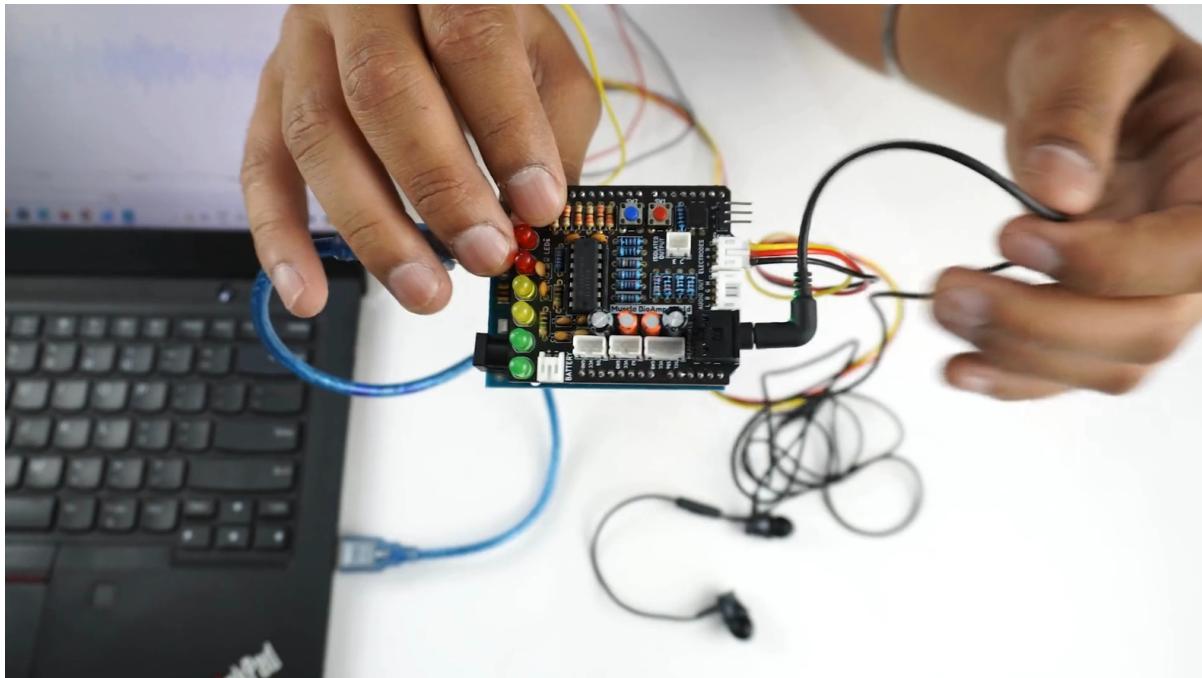
### 7.8.1 Listening EMG on speakers

1. Connect the BioAmp AUX cable on a bluetooth speaker that have 3.5mm jack support.
2. Switch on the speaker and turn the volume to maximum.
3. Flex and listen to your muscles.



### **7.8.2 Listening EMG on a wired earphones/headphones**

1. Plug your wired earphones or headphones on the 3.5mm jack of BioAmp v1.5.
2. Plug it in your ears.
3. Flex and listen to your muscles.



### **7.9 Step 9: Controlling a servo motor**

Connect the servo claw to Muscle BioAmp Shield.

Copy paste the Arduino Sketch given below in Arduino IDE:

Servo Controller: [https://github.com/upsidedownlabs/Muscle-BioAmp-Arduino-Firmware/blob/main/5\\_ServoControl/5\\_ServoControl.ino](https://github.com/upsidedownlabs/Muscle-BioAmp-Arduino-Firmware/blob/main/5_ServoControl/5_ServoControl.ino)

Make sure you have selected the right board and COM port. Now upload the code, and flex your arm to control the servo claw in real time.

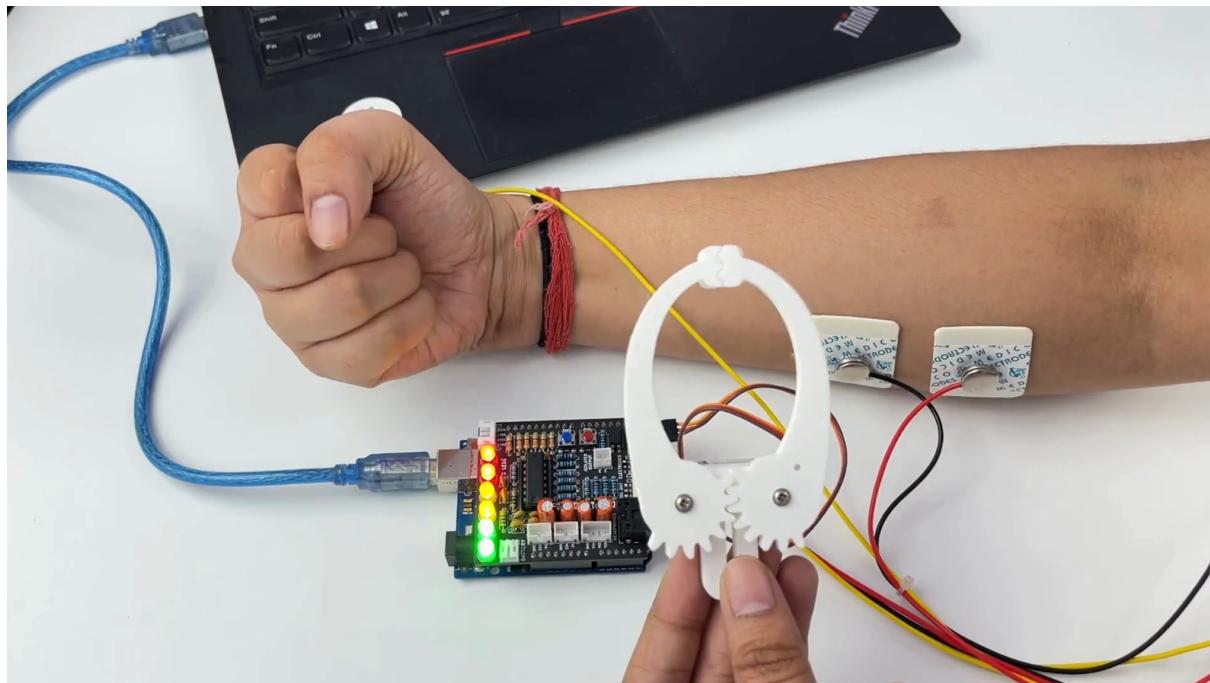
### **7.10 Step 10: Controlling a servo claw**

Connect the servo claw to Muscle BioAmp Shield.

Copy paste the Arduino Sketch given below in Arduino IDE:

Claw Controller: [https://github.com/upsidedownlabs/Muscle-BioAmp-Arduino-Firmware/tree/main/4\\_ClawController](https://github.com/upsidedownlabs/Muscle-BioAmp-Arduino-Firmware/tree/main/4_ClawController)

Make sure you have selected the right board and COM port. Now upload the code, and flex your arm to control the servo claw in real time.



## 7.11 Step 11: Connecting 9V battery

Till now, the power for the EMG system was coming from the laptop via USB cable of Arduino Uno but there can be 2 ways in which you can make the system portable:

- **Using 9V battery:** Directly connect a 9V battery to Muscle BioAmp Shield using a 9V snap cable.
- **Using Power Bank:** Instead of connecting the USB cable of Arduino Uno to laptop, you can directly connect it to power bank.

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**Note:** Do not use 9V battery while controlling a servo claw using Muscle BioAmp Shield. Instead connect the Arduino UNO to a power bank or directly to your laptop.

---

## 7.12 Step 12: Other functionalities you can explore

### 7.12.1 Using I2C ports

There are 2 I2C ports available on Muscle BioAmp Shield and you can connect hundreds of devices having I2C compatibility using the 4-pin JST PH 2.0 mm STEMMA cables provided.

Some of the examples are: OLED screens, character displays, temperature sensors, accelerometers, gyroscopes, light sensors, BioAmp Hardware, etc.

### **7.12.2 Using STEMMA Digital port**

Connect Arduino Uno's D6 digital I/O pins using STEMMA digital connectors.

### **7.12.3 Using STEMMA Analog port**

Connect Arduino Uno's A2 analog input pins using STEMMA analog connectors.

### **7.12.4 Using user buttons**

Program the 2 user buttons according to your project requirements.