DIY Neuroscience Kit Pro

Upside Down Labs

Apr 18, 2025

CONTENTS

CHAPTER

ONE

DIY NEUROSCIENCE KIT PRO

This is the advanced DIY Neuroscience Kit with Muscle BioAmp Shield - an EMG Shield for Arduino UNO! The shield offers multiple plug-and-play options, and additional data acquisition while the BioAmp EXG Pill enhances versatility by enabling the measurement of various biopotential signals, including EEG (brain), EOG (eyes), EMG (muscles), and ECG (heart). Start your journey of discovery, as you build exciting projects, develop HCI/BCI applications, and gain valuable insights.

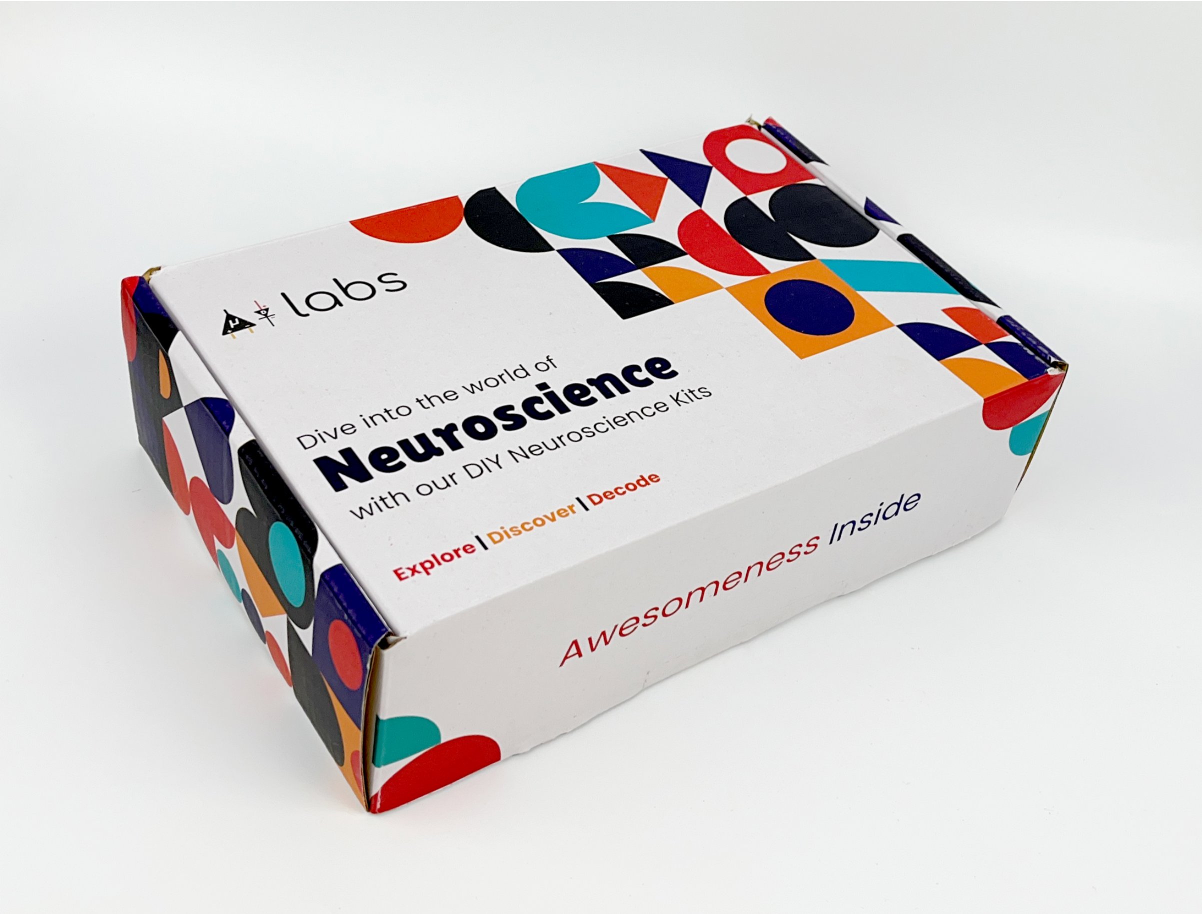


Fig. 1: DIY Neuroscience Kit Pro

1.1 Contents of the kit

Kit Contents	Qty
BioAmp EXG Pill	1
BioAmp Bands	3
BioAmp Cable	1
Jumper Cables (set of 3)	1
Skin Preparation Kit	1
Electrode Gel	1
Gel Electrodes	24+100
Repositionable gel electrodes (3 pc)	1
Arduino UNO R3/Arduino UNO R4 Minima	1
Servo Claw	1
Muscle BioAmp Shield Kit (With 1 BioAmp Cable, 6 STEMMA Cables, 9V snap cable, BioAmp AUX Cable, Muscle BioAmp Band, 24 gel electrodes, & Muscle BioAmp Shield)	1

Click on the link below to see the unboxing of the kit:

https://youtu.be/Sn389Q7Izy4

1.2 Software requirements

To use your DIY Neuroscience Kit Pro, you will need the softwares mentioned below. Instructions on how to use them are provided later in the guide.

- Arduino IDE v1.8.19 (legacy IDE) (Download this to upload Chords arduino firmware to your development board)
- Chords Web (Use this open-source web application to visualize your biopotential signals)
- Visual Studio Code (or any other Code editor of your choice)
- Python (To run Chords-Python script)
- Chords Python (Use this open-source python script designed to record and visualize biopotential signals)

Note

1. The Chords Arduino firmware is identical for both Chords Web and Chords Python, so you only need to upload the code once, and you're all set.
2. You can choose either Chords Web or Chords Python to record and visualize your biopotential signals based on your needs. If you're curious, you can try both one at a time.

1.3 Using the kit

DIY Neuroscience Kit Pro includes 2 biopotential sensors:

1. BioAmp EXG Pill (Assembled)
2. Muscle BioAmp Shield v0.3 (Assembled)

You can use these sensors either separately or connect them together to create a 2-channel EXG acquisition system wherein channel 1 can be used to record EMG signals and channel 2 allows you to record all the biopotential signals from your body (EMG, ECG, EOG, EEG).

1.3.1 Step 1: Using BioAmp EXG Pill

BioAmp EXG Pill is a small, powerful analog-front-end (AFE) biopotential signal-acquisition board that can be paired with any microcontroller unit (MCU) or single-board computer (SBC) with an analog-to-digital converter (ADC) such as Arduino UNO & Nano, Adafruit QtPy, STM32 Blue Pill, BeagleBone Black, and Raspberry Pi Pico, to name just a few. It also works with any dedicated ADC, like the Texas Instruments ADS1115 and ADS131M0x, among others.

Note

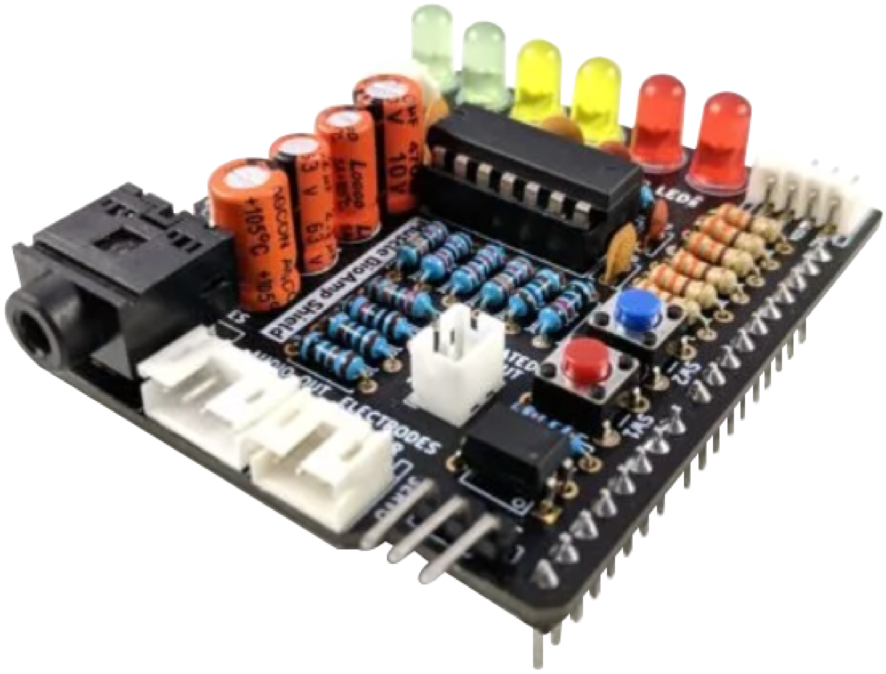
Checkout the complete documentation on *BioAmp EXG Pill* which includes how to use the sensor, record various biopotential signals from your body (ECG, EMG, EOG, EEG) and make different HCI/BCI projects using it.

1.3.2 Step 2: Using Muscle BioAmp Shield

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).

Note

Checkout the complete documentation on *Muscle BioAmp Shield* which includes how to use the sensor, record/visualise/listen muscle signals and make different HCI projects using it.



1.3.3 Step 3: Using the sensors together

We believe that you have already gone through the documentation of BioAmp EXG Pill & Muscle BioAmp Shield using the links provided in step 1 and 2 respectively.

You have covered the basic steps till now including connections with the development board, skin preparation, electrodes placements, and recording the signals from your body.

Let's become a PRO and create a 2-channel EXG aquisition system.

a. Connecting Muscle BioAmp Shield to MCU/ADC

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

b. Configure for ECG/EMG (optional)

BioAmp EXG Pill is by default configured for recording EEG or EOG but if you want to record good quality ECG or EMG, then it is recommended to configure it by making a solder joint as shown in the image.

> **Note**
>
> Even without making the solder joint the BioAmp EXG Pill is capable of recording ECG or EMG but the signals would be more accurate if you configure it.

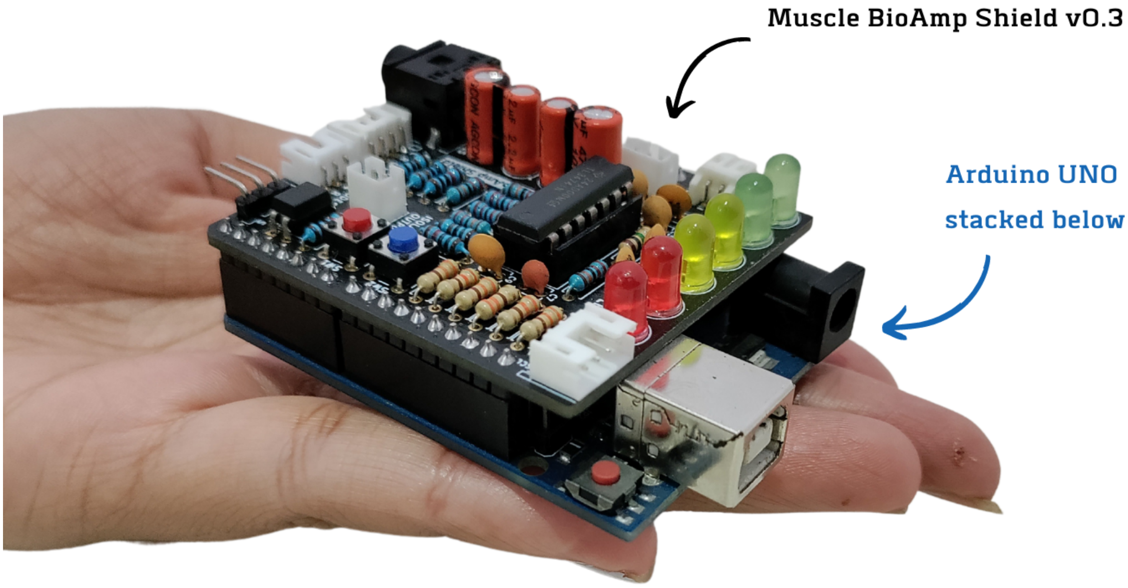


Fig. 2: Stacking Muscle BioAmp Shield on top of Arduino

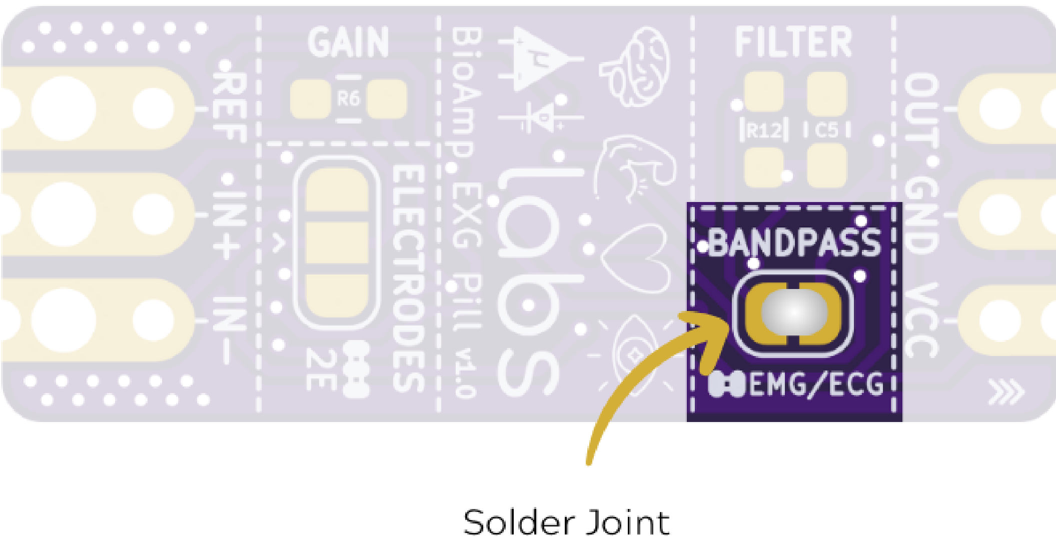


Fig. 3: Configure BioAmp EXG Pill for EMG/ECG

c. Connecting sensors together

Connect the BioAmp EXG Pill to the A2 port of Muscle BioAmp Shield via 3-pin STEMMA cable which has JST PH 2.0mm connector on one end and 3 female jumpers on the other end.

Muscle BioAmp Shield	BioAmp EXG Pill
GND	GND
VCC	5V
A2	OUT

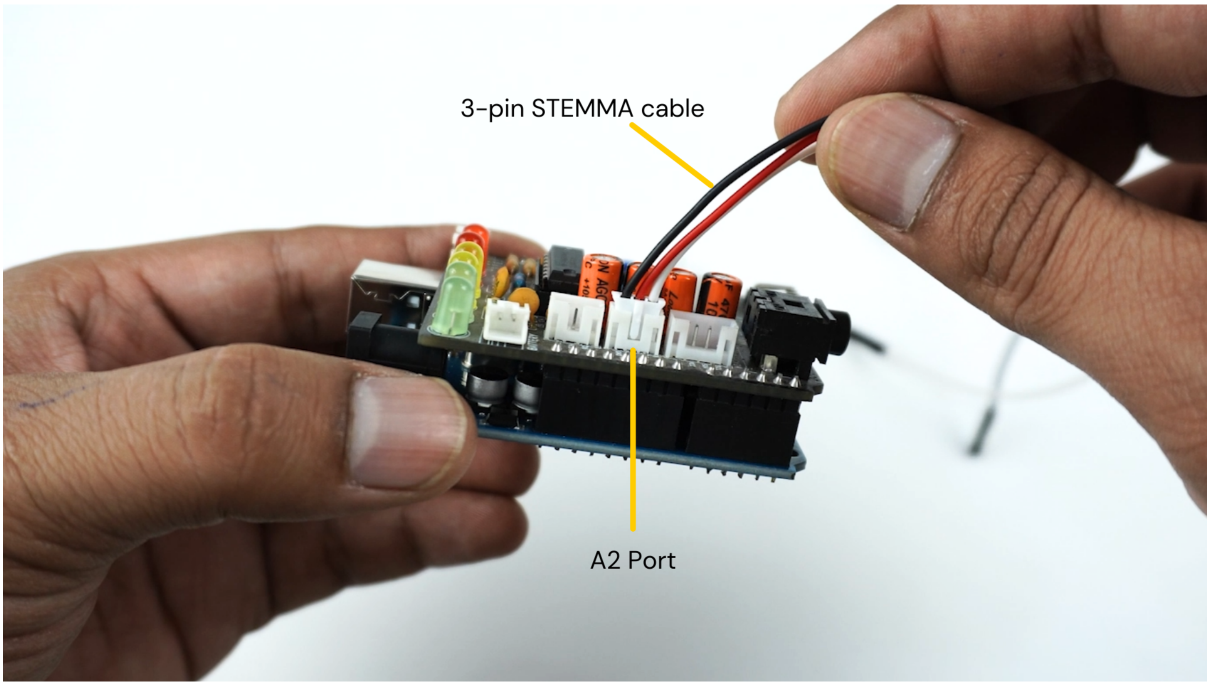


Fig. 4: Inserting JST PH connector in A2 port of Muscle BioAmp Shield

d. Connecting electrode cables

Connect one BioAmp cable to BioAmp EXG Pill and another BioAmp cable to Muscle BioAmp Shield by inserting the cable ends into the respective JST PH connectors as shown below:

e. Skin Preparation

We'll create a 2-channel EMG acquisition system and to do so, we'll be using both the sensors to record EMG signals from the ulnar nerve of both the hands, Thus, prepare the skin accordingly.

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 Guide*.

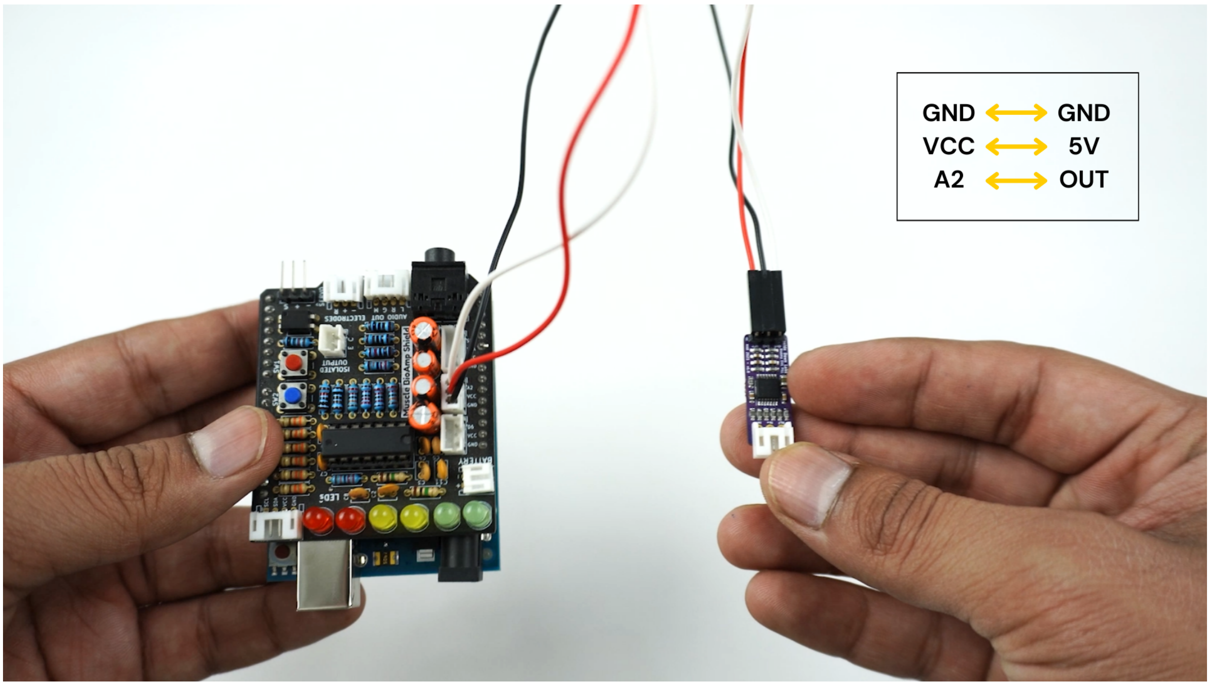


Fig. 5: Muscle BioAmp Shield to BioAmp EXG Pill connections

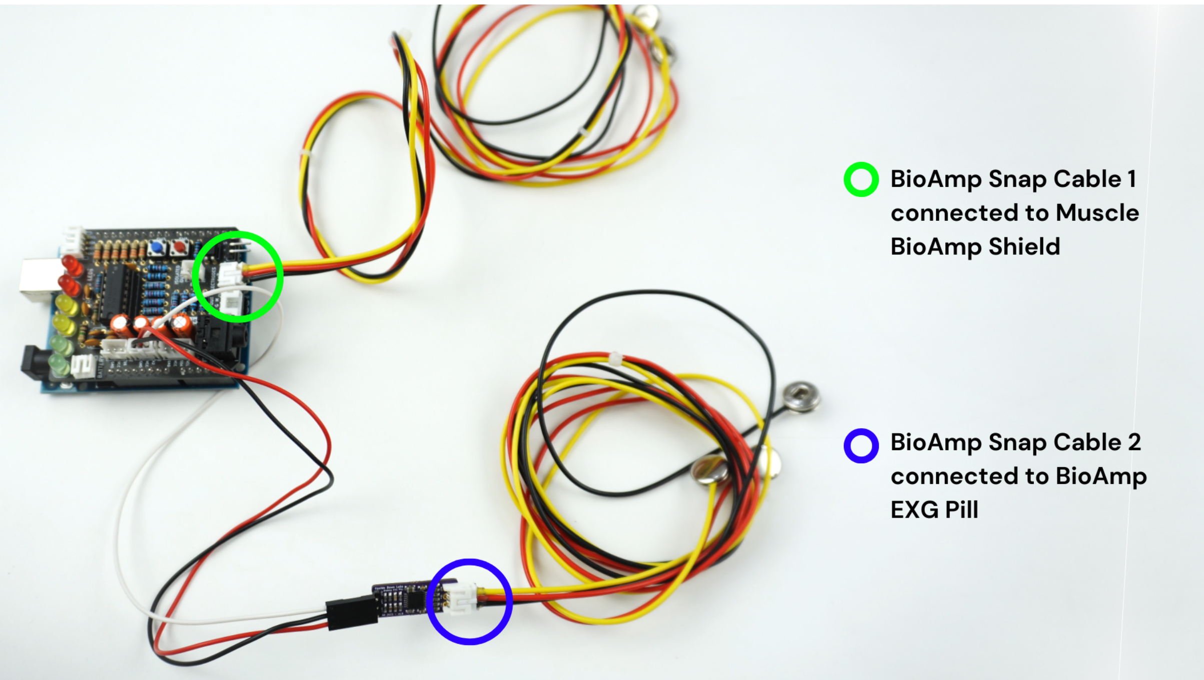


Fig. 6: Connecting BioAmp Cables to the sensors

f. Electrodes placement

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.

Using gel electrodes

1. Snap the BioAmp Cable connected to BioAmp EXG Pill to gel electrodes.
2. Peel the plastic backing from electrodes.
3. Place the IN+ and IN- cables on the left arm near the ulnar nerve & REF (reference) at the back of your left hand as shown below.
4. Now snap the BioAmp Cable connected to Muscle BioAmp Shield to gel electrodes.
5. Peel the plastic backing from electrodes.
6. Place the IN+ and IN- cables on the right arm near the ulnar nerve & REF (reference) at the back of your right hand as shown below.

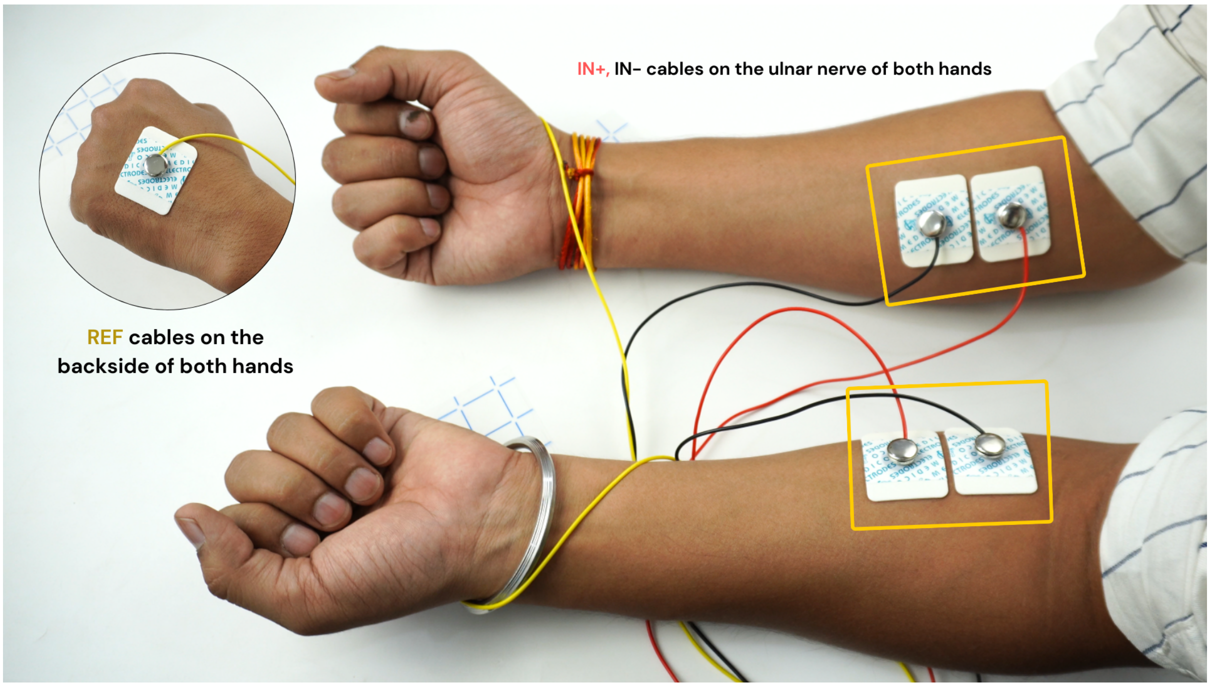


Fig. 7: Gel electrodes placement

Using Muscle BioAmp Band

1. Snap the BioAmp Cable connected to BioAmp EXG Pill on Muscle BioAmp Band in a way such that IN+ and IN- are placed on the left arm near the ulnar nerve & REF (reference) on the far side of the band.
2. Snap the BioAmp Cable connected to Muscle BioAmp Shield on Muscle BioAmp Band in a way such that IN+ and IN- are placed on the right arm near the ulnar nerve & REF (reference) on the far side of the band.
3. Now put a small drop of electrode gel between the skin and metallic parts of BioAmp Cables to get the best results.

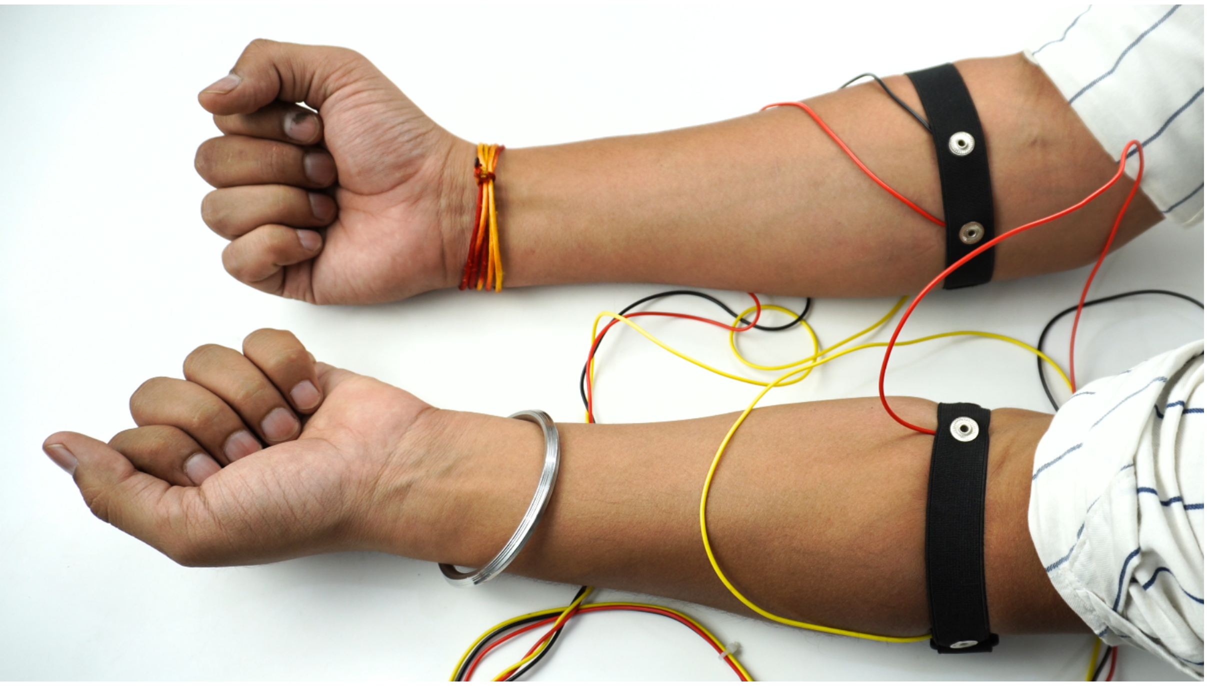


Fig. 8: Muscle BioAmp Band placement

Tip

Visit the complete documentation on how to *assemble and use the BioAmp Bands* or follow the youtube video given below.

Tutorial on how to use the band:

https://youtu.be/xYZdw0aesa0

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.

g. Uploading the code

Connect Arduino Uno to your laptop using the USB cable (Type A to Type B). Download the github repository given below:

Muscle BioAmp Arduino Firmware

Go to the folder `8_EMGScrolling`, open the arduino sketch `8_EMGScrolling.ino` in Arduino IDE.

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 Arduino UNO board and reopen the menu. The entry that disappears should be the right COM port. Now upload the code.

Important

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

h. Testing the connections

Go to `tools` from the menu bar, click on `serial monitor` to open it or click on the icon on the top right corner. Try flexing both of your arms one-by-one. The output values should be 0 at this point.

Press the `SW1 button` on Muscle BioAmp Shield. Now you'll see green LED glowing on the LED bar. When you flex your right arm, you'll get output value 1 on the serial monitor and red LED will glow. Similarly, when you flex your left arm, you'll get output value 2 and yellow LED will glow.

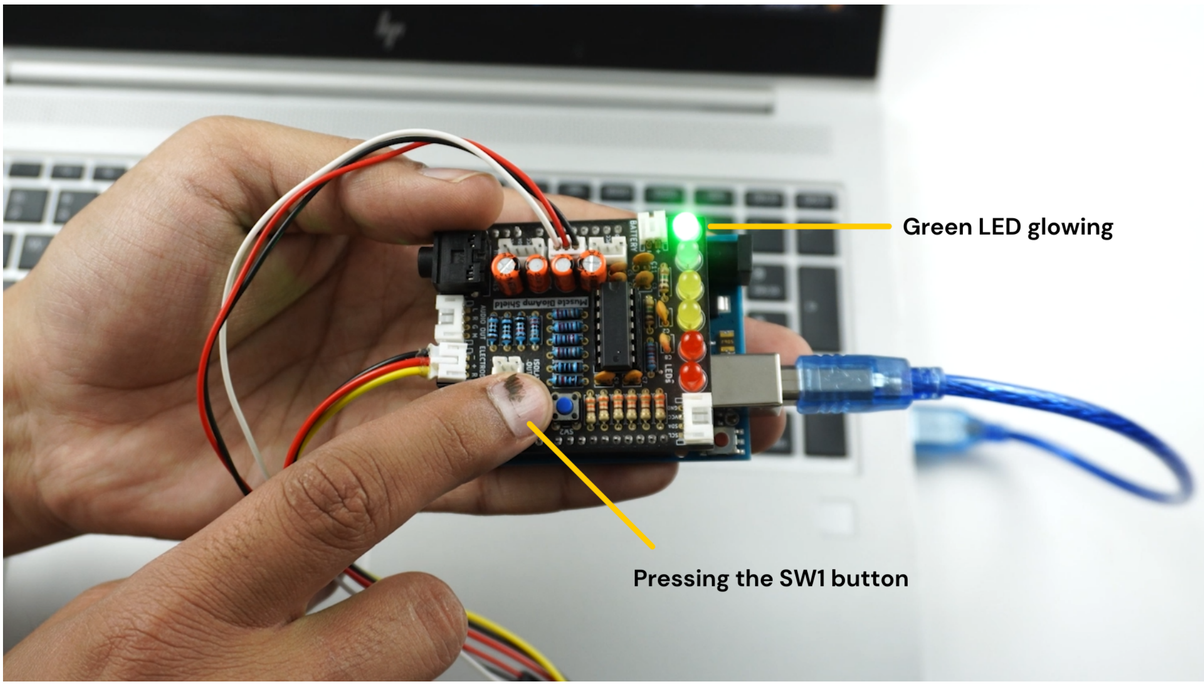


Fig. 9: Press the SW1 button to start getting the output

i. Running python script

Open Visual Studio Code, click on File > Open folder to open the folder `8_EMGScrolling`.

Open the terminal, and ensure that the path is configured to the location of the `requirement.txt` file.

To install all the modules that are required to run the Python script, write the given command in the terminal:

```
pip install -r requirements.txt
```

Open `EMG_Scroll.py` and change the COM Port in the code (line 14) as per the COM Port you selected in Arduino IDE. Save the file by clicking CTRL + S.

```
# Arduino serial port interface
ser = serial.Serial('COM12', 115200, timeout=1)
```

Run the Python script `EMG_Scroll.py` by writing the given command in the terminal:

```
python EMG_Scroll.py
```

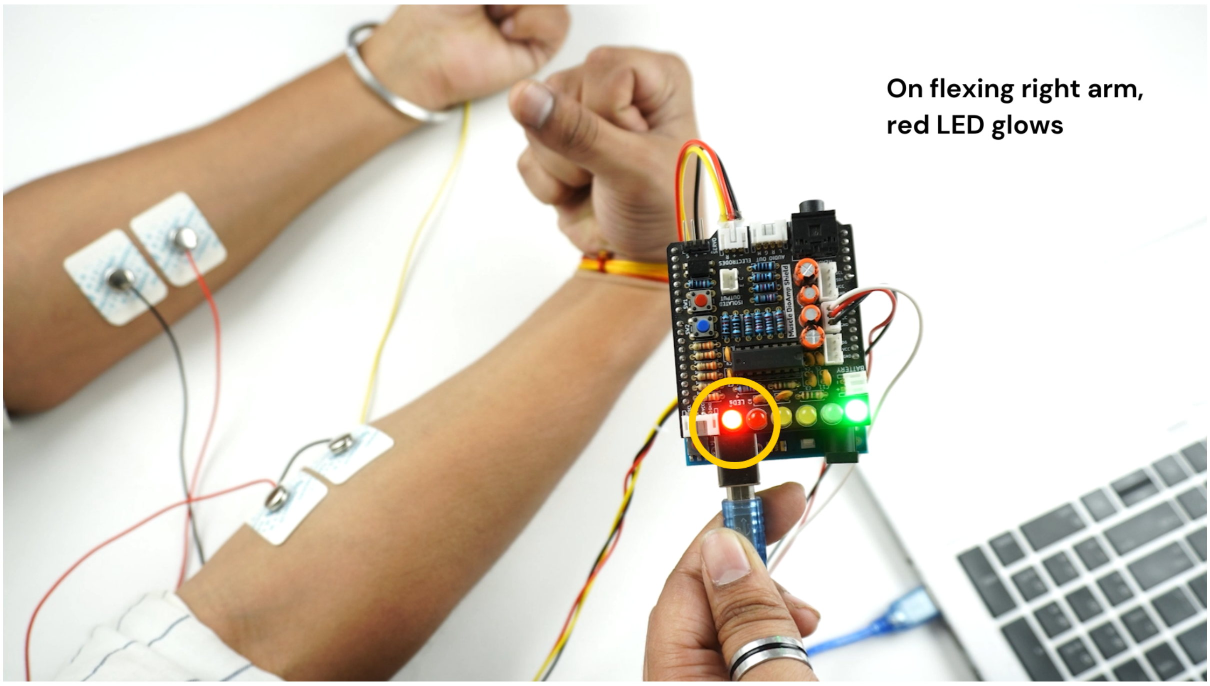


Fig. 10: Flex the right arm, red LED glows

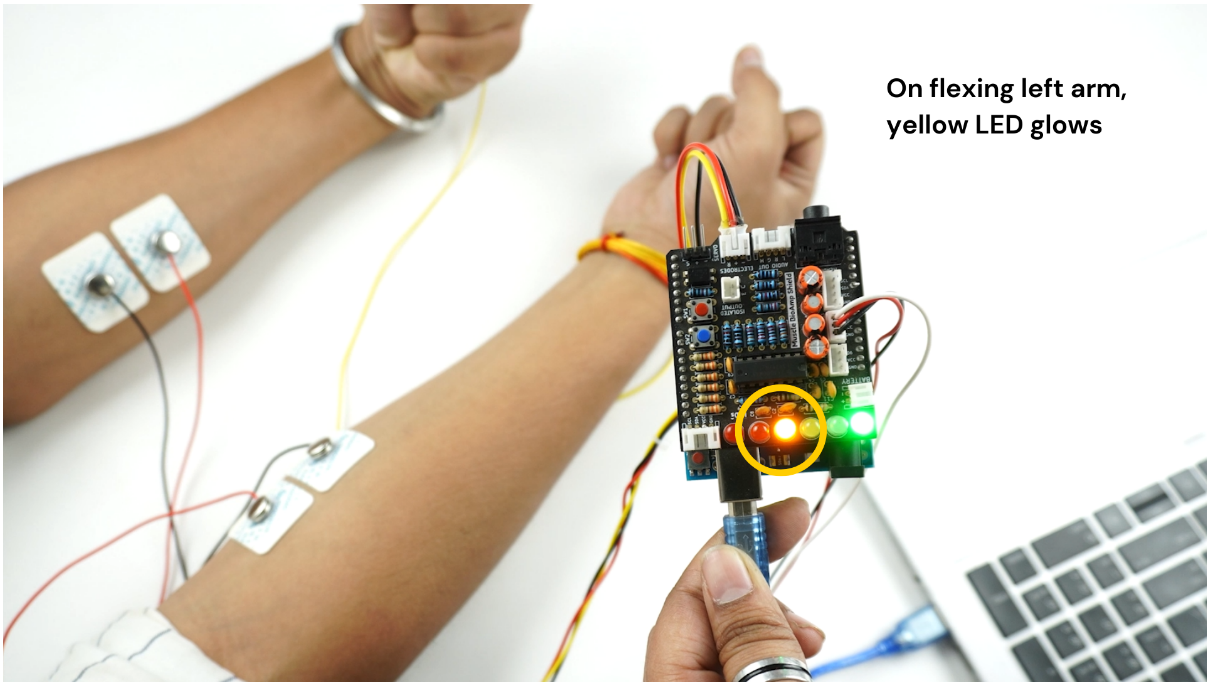


Fig. 11: Flex the left arm, yellow LED glows

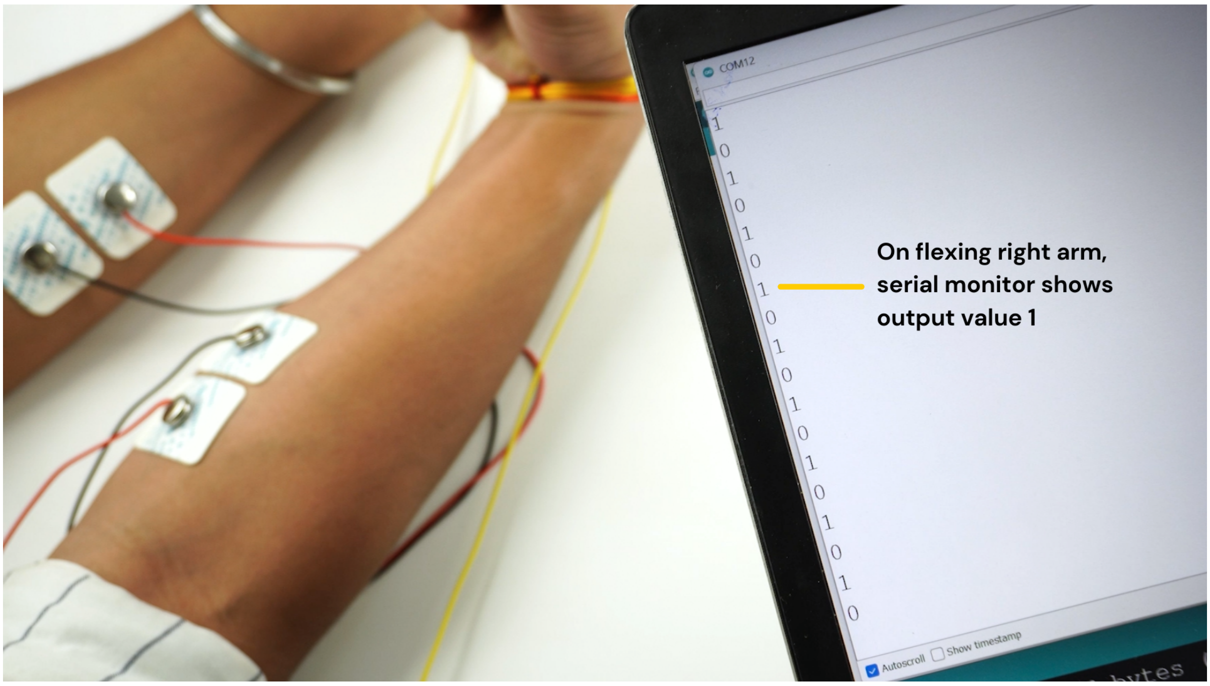


Fig. 12: Flex the right arm, serial monitor shows output value 1

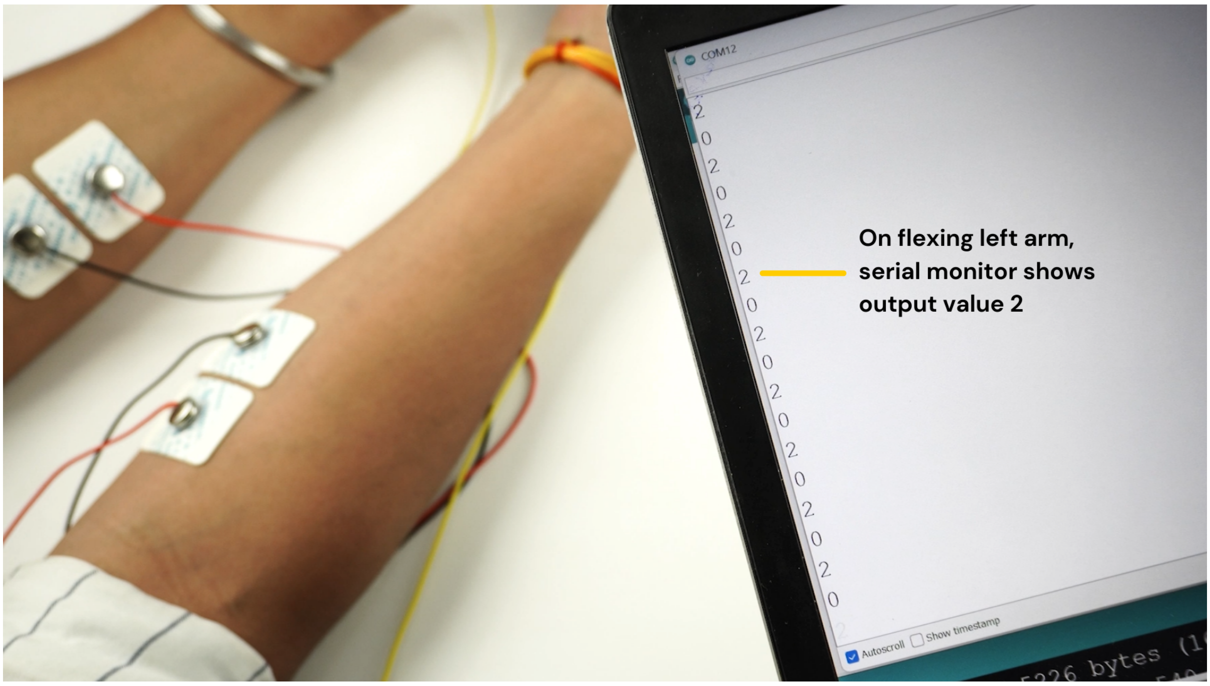
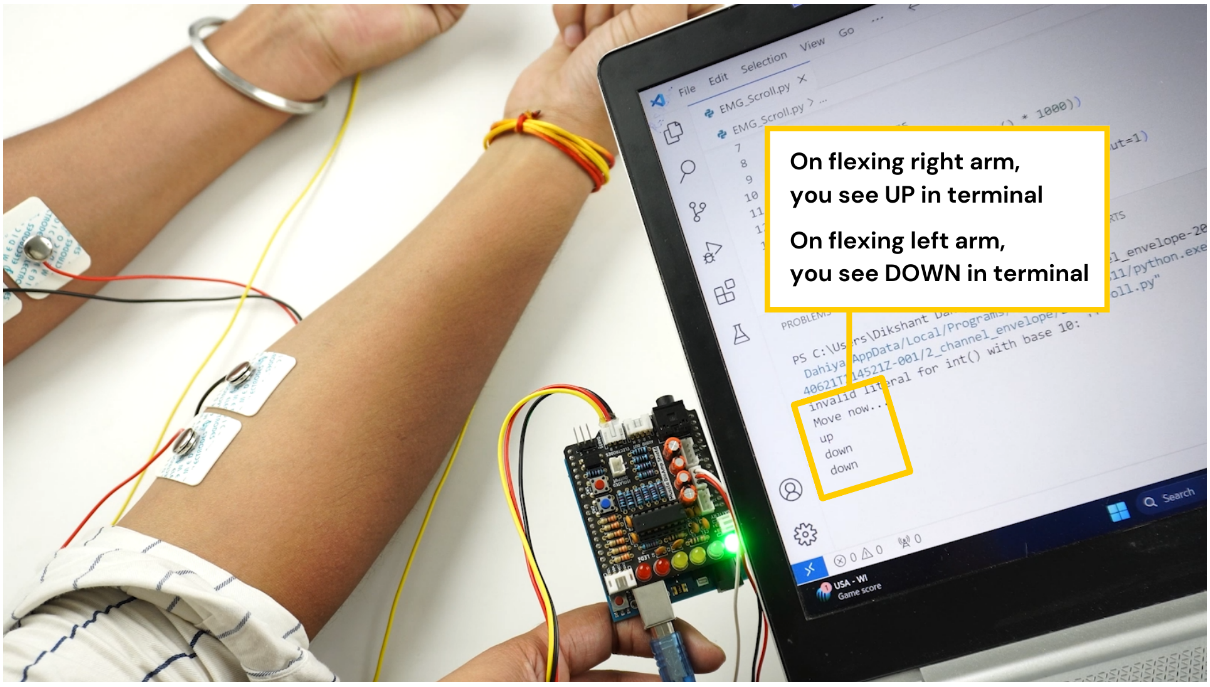


Fig. 13: Flex the left arm, serial monitor shows output value 2

j. Scrolling using EMG signals

Press the `SW1 button` on Muscle BioAmp Shield again.

In the terminal, you will see Move Now prompt. When you flex your right arm, you'll see UP in the terminal. Similarly, when you move your left arm, you'll see DOWN in the terminal.



Now, open youtube shorts on your laptop and start scrolling using your muscle signals.

> **Note**
>
> What's happening in the background? Whenever an EMG signal is detected, it acts as a trigger to emulate UP or DOWN key on the keyboard.

k. Calibrating the code

Changes in Arduino Sketch

Modify the threshold values on **lines 73 and 74**. Threshold 1 is for the EMG signals recorded from the Muscle BioAmp Shield, and threshold 2 is for the EMG signals recorded from the BioAmp EXG Pill.

Uncomment line 71 in the Arduino code and navigate to Tools > Serial Plotter. You'll see two plots showing the EMG signals of both of your arms. Flex your right arm and observe the peak value on the y-axis. If the peak value is around 240, you can set threshold 1 anywhere between 150 to 200. The lower the threshold value, the easier it is to trigger the output as UP or DOWN, and vice versa. Repeat the process to determine the threshold 2 value for your left arm.

After setting the thresholds, comment out line 71.

Changes in Python script

Adjust the latency value on **line 51**. A higher latency value will make the output less responsive, requiring you to flex and hold longer to scroll through the screen. A lower latency value will make the output more responsive, allowing you to scroll through the screen more easily.

I. Conclusion

This was just a demonstration to show you how both the sensors (BioAmp EXG Pill & Muscle BioAmp Shield) can be used together to create a 2-channel EXG acquisition system. In this project, we used BioAmp EXG Pill to record EMG signals, but it can also be used to record other biopotential signals as well like ECG, EOG, or EEG.

1.4 Some project ideas

You can find step-by-step tutorials for various HCI/BCI projects on our Instructables.

1.4.1 Projects made using BioAmp EXG Pill

1. Controlling video game using brainwaves (EEG)
2. Visualising electrical impulses from eyes (EOG)
3. Recording EEG from visual cortex part of brain
4. Recording EEG from prefrontal cortex part of brain
5. Eye blink detection
6. Creating a drowsiness detector
7. Record publication-grade ECG
8. Measuring heart rate
9. Detecting heart beats
10. Record publication-grade EMG
11. Detecting up and down movement of eyes

1.4.2 Projects made using Muscle BioAmp Shield

1. Record, visualise, and listen to EMG signals
2. Controlling 3d-printed servo claw using EMG
3. Controlling prosthetic hand using EMG
4. Building the ultimate servo claw game
5. Building muscle strength game

1.4.3 Projects made using the sensors together

1. Control dino game using eye blinks
2. Control servo claw using EOG
3. Visualize2-chEMGonLCDdisplaymodulehttps://www.instructables.com/Visualizing-2-Channel-EMG-on-LCD-Display-Mo
4. Control video games using 2-ch EMG

These are some of the project ideas but the possibilities are endless. So create your own Human Computer Interface (HCI) and Brain Computer Interface (BCI) projects and share them with us at `contact@upsidedownlabs.tech`

CHAPTER

TWO

BIOAMP EXG PILL

v1.0

2.1 Overview

BioAmp EXG Pill is a small, powerful analog-front-end (AFE) biopotential signal-acquisition board that can be paired with any microcontroller unit (MCU) or single-board computer (SBC) with an analog-to-digital converter (ADC) such as Arduino UNO & Nano, Adafruit QtPy, STM32 Blue Pill, BeagleBone Black, and Raspberry Pi Pico, to name just a few. It also works with any dedicated ADC, like the Texas Instruments ADS1115 and ADS131M0x, among others.

Note

It is recommended to use Arduino UNO R4 while recording biopotential signals since it has 14-bit ADC and can record the signals more accurately.

2.2 What makes it different?

1. Record publication-quality biopotential signals like ECG, EMG, EOG, or EEG.
2. Small size (25.4 x 10.0mm) allows easy integration into mobile and space-constrained projects.
3. Powerful noise rejection makes it usable even when the device is close to the AC mains supply.
4. Any 1.5 mm diameter wire can be used as a strain-relieving electrode cable, making it very cost-effective.
5. Configure the gain, band pass filter and electrode count according to your requirements.

2.3 Features & Specifications

Operating Voltage	3.3/5 V
Input Impedance	10^12 ohm
Compatible Hardware	Any development board with an ADC (Arduino UNO & Nano, Adafruit QtPy, STM32 Blue Pill, BeagleBone Black, Raspberry Pi Pico, to name just a few) or any standalone ADC of your choice
BioPotentials	EMG, ECG, EOG, EEG (configurable band-pass, by default configured for EEG & EOG)
No. of channels	1
Electrodes	2 or 3 (By default configured for 3 electrodes)
Dimensions	25.4 x 10 mm
Open Source	Hardware + Software

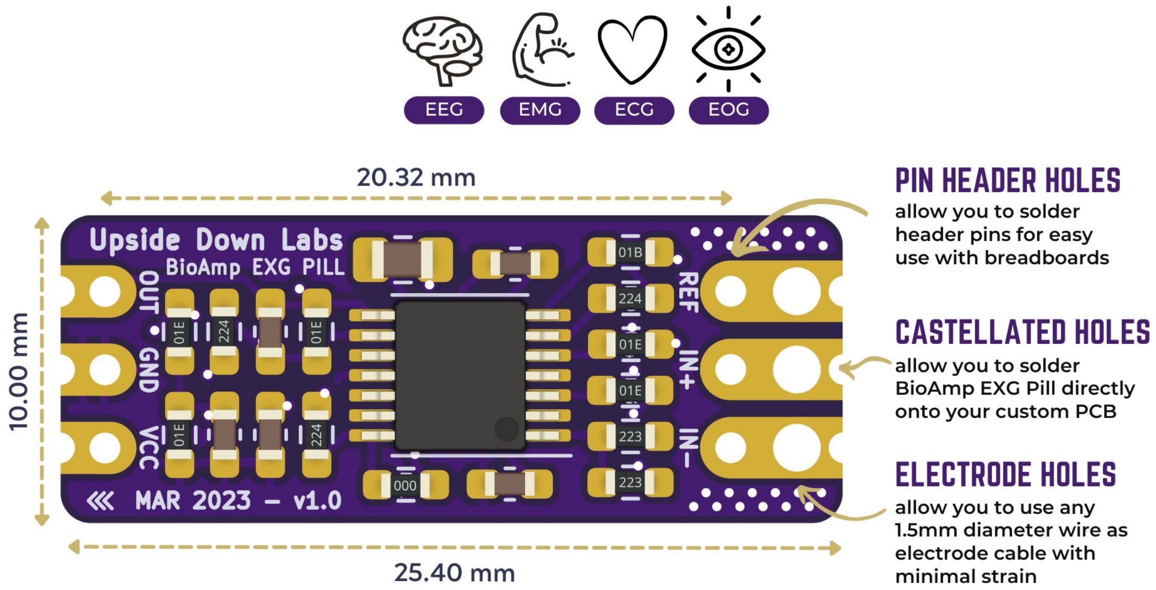
2.4 Board layout

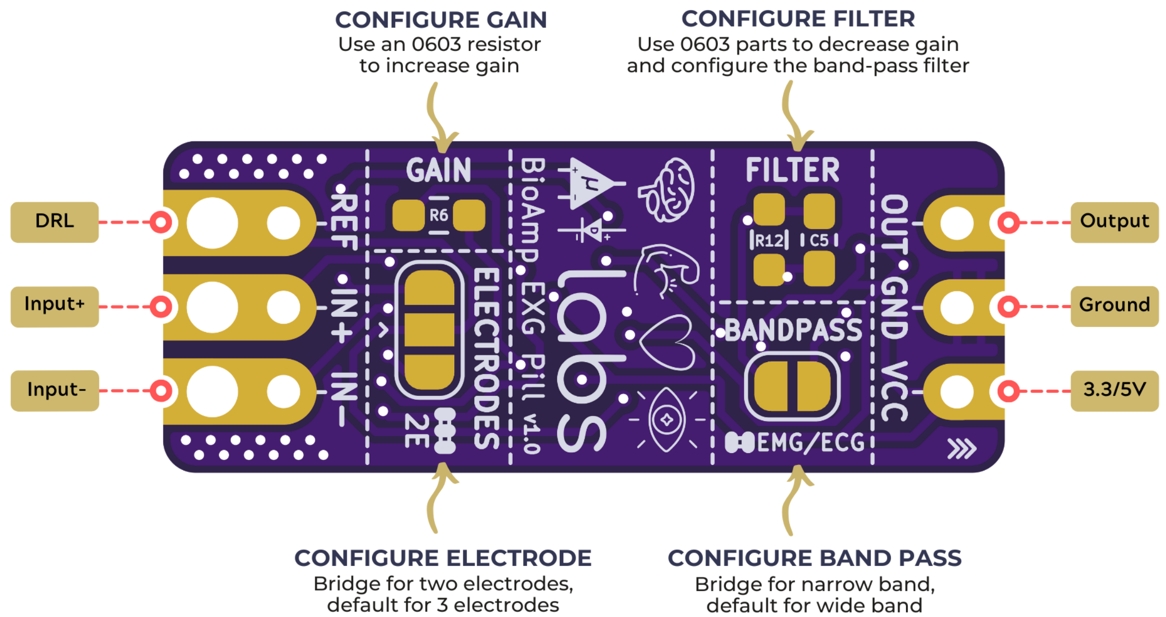
BioAmp EXG Pill's elegant design allows it to be used in 3 ways:

1. Pin-header holes allow you to solder (berg strip) pin headers for easy use with a breadboard.
2. Castellated holes allow you to solder BioAmp EXG Pill directly onto a custom PCB that requires biopotential-amplification capabilities.
3. Electrode holes allow you to use any 1.5 mm diameter wire as an electrode cable with minimal strain.

2.4.1 BioAmp EXG Pill is fully configurable

1. BioAmp EXG Pill is optimised to record all your biopotential signals (EMG/ECG/EOG/EEG) accurately thus it is not recommended to change its gain. But in case you want to do so, use a 0603 resistor at `R6`. Decrease gain and configure the bandpass filter by using 0603 parts at `R12` and `C5`. Band limiting is very useful for EOG and EEG recording. Also, the signal sometimes clips while recording an ECG with electrodes very close to the heart. Creating a solder jumper for a band-pass filter helps with that. By default, BioAmp EXG Pill is configured to record EEG and EOG but you can bridge the pads (below bandpass) with solder to make it configurable for EMG and ECG.
2. The normal method of operation for best-quality signal amplification is to use 3 electrodes by default but you can bridge the pads (below electrodes) to make it configurable for 2 electrodes. The 2-electrode mode is specifically included for projects like heart (ECG) patches for HRV. It's only supposed to be used with a


EEG
EMG
ECG
EOG
20.32 mm
10.00 mm
25.40 mm
Upside Down Labs
BioAmp EXG PILL
OUT
GND
VCC
REF
IN+
IN−
MAR 2023 – v1.0
PIN HEADER HOLES
allow you to solder header pins for easy use with breadboards
CASTELLATED HOLES
allow you to solder BioAmp EXG Pill directly onto your custom PCB
ELECTRODE HOLES
allow you to use any 1.5mm diameter wire as electrode cable with minimal strain


CONFIGURE GAIN
Use an 0603 resistor to increase gain
CONFIGURE FILTER
Use 0603 parts to decrease gain and configure the band-pass filter
DRL
Input+
Input-
Output
Ground
3.3/5V
GAIN
R6
REF
IN+
IN−
ELECTRODES
2E
BioAmp EXG Pill v1.0
labs
FILTER
R12
C5
BANDPASS
EMG/ECG
OUT
GND
VCC
CONFIGURE ELECTRODE
Bridge for two electrodes, default for 3 electrodes
CONFIGURE BAND PASS
Bridge for narrow band, default for wide band

battery-operated setup and is quite prone to high interference noise due to a lack of proper reference on the body (This option is not recommended for most operations)

2.5 Software requirements

To use BioAmp EXG Pill, you will need the softwares mentioned below. Instructions on how to use them are provided later in the guide.

- Arduino IDE (Download this to upload Chords arduino firmware to your development board)
- Chords Web (Use this open-source web application to visualize your biopotential signals)
- Visual Studio Code (or any other Code editor of your choice)
- Python (To run Chords-Python script)
- Chords Python (Use this open-source python script designed to record and visualize biopotential signals)

Note

1. The Chords Arduino firmware is identical for both Chords Web and Chords Python, so you only need to upload the code once, and you're all set.
2. You can choose either Chords Web or Chords Python to record and visualize your biopotential signals based on your needs. If you're curious, you can try both one at a time.

2.6 Using the Hardware

If you have received the assembled BioAmp EXG Pill then you can skip the step 1 and move on to step 2.

2.6.1 Step 1: Solder Connectors

Insert the provided BioAmp cable's JST PH connector and header pins from top as shown in the image and solder them from below.

2.6.2 Step 2 (optional): Configure for ECG/EMG

BioAmp EXG Pill is by default configured for recording EEG or EOG but if you want to record good quality ECG or EMG, then it is recommended to configure it by making a solder joint as shown in the image.

Note

Even without making the solder joint the BioAmp EXG Pill is capable of recording ECG or EMG but the signals would be more accurate if you configure it.

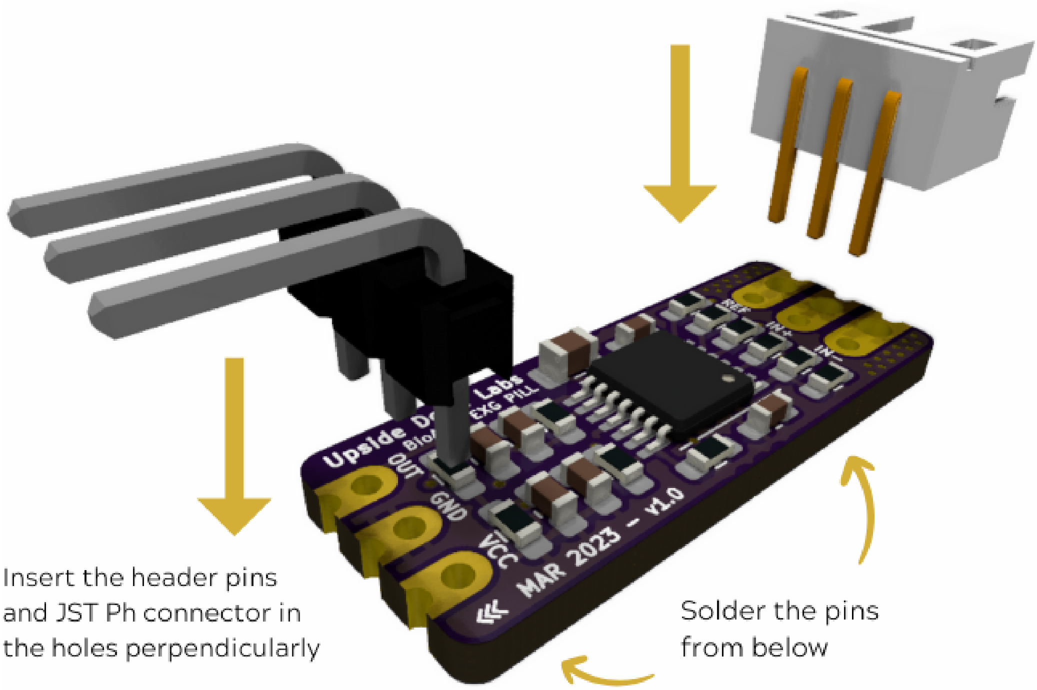


Fig. 1: *Soldering the connector & header pins on BioAmp EXG Pill*

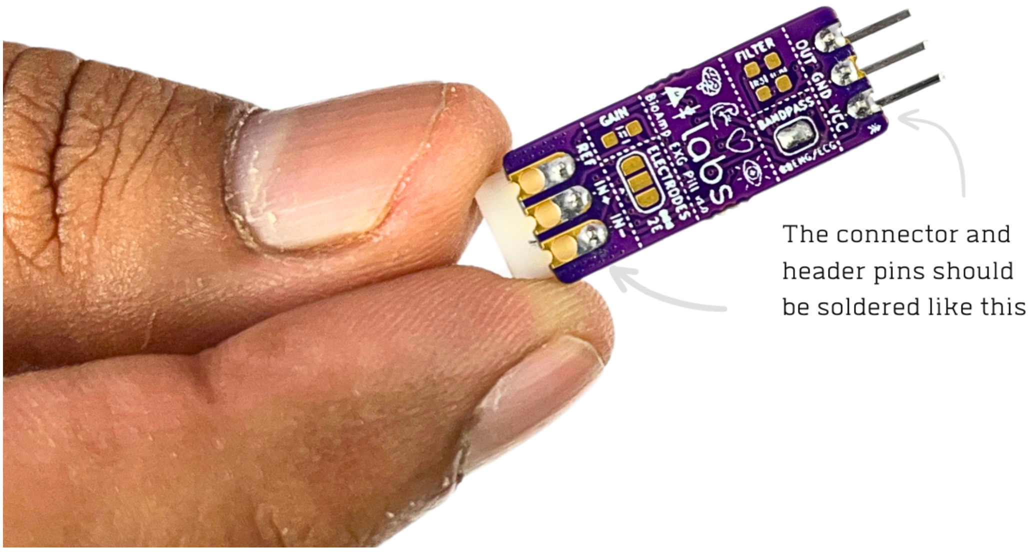
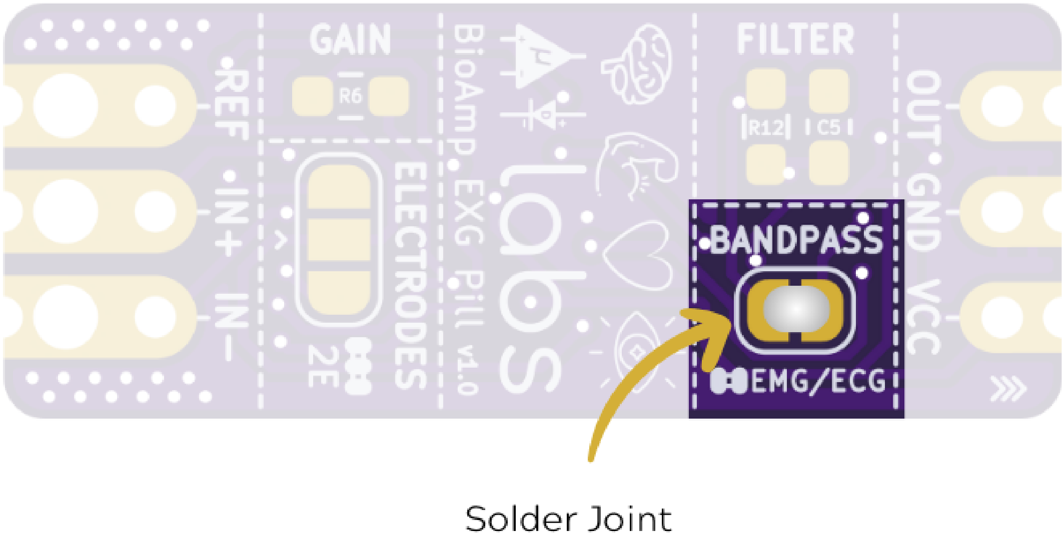


Fig. 2: *After soldering, BioAmp EXG Pill should look like this*



2.6.3 Step 3: Connect MCU/ADC

Connect your BioAmp EXG Pill to your MCU/ADC as per the connection table shown below:

Table 1: BioAmp to MCU/ADC connection

BioAmp	MCU/ADC
VCC	3.3/5V
GND	GND
OUT	ADC Input

If you are connecting `OUT` pin of BioAmp to any other analog pin of your development board, then you will have to change the INPUT PIN in the Arduino sketch accordingly.

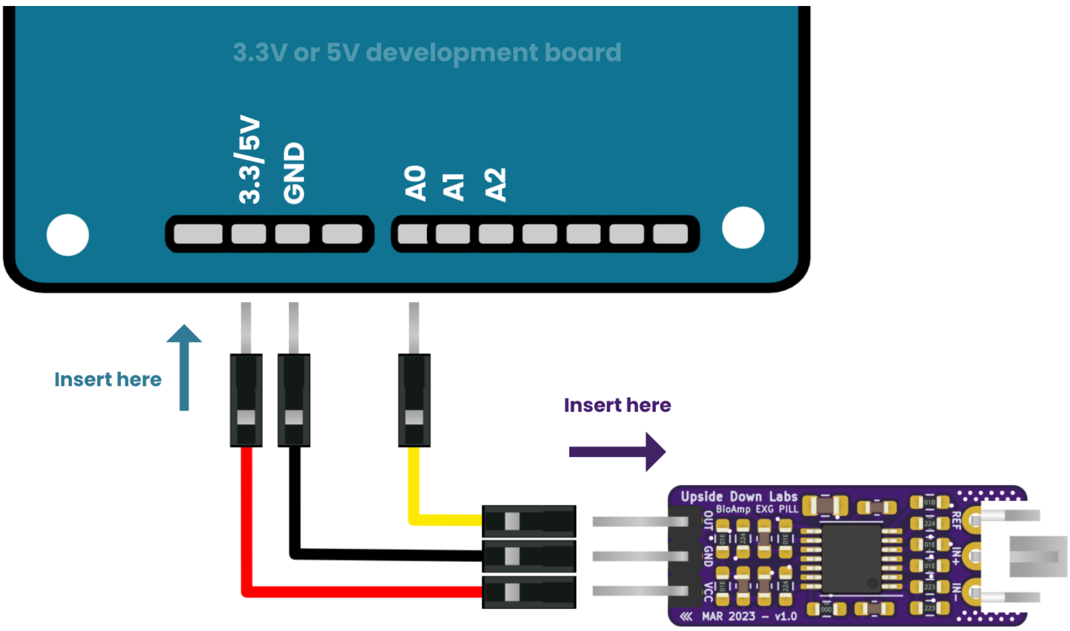


Fig. 3: *Connections with 3.3/5V development board*

Warning

Take precautions while connecting to power, if power pins (VCC/GND) are to be swapped, your BioAmp EXG Pill will be fried and it'll become unusable (DIE).

2.6.4 Step 4: Connecting electrode cable

Connect the BioAmp cable to BioAmp EXG Pill by inserting the cable end in the JST PH connector as shown in the graphic below.

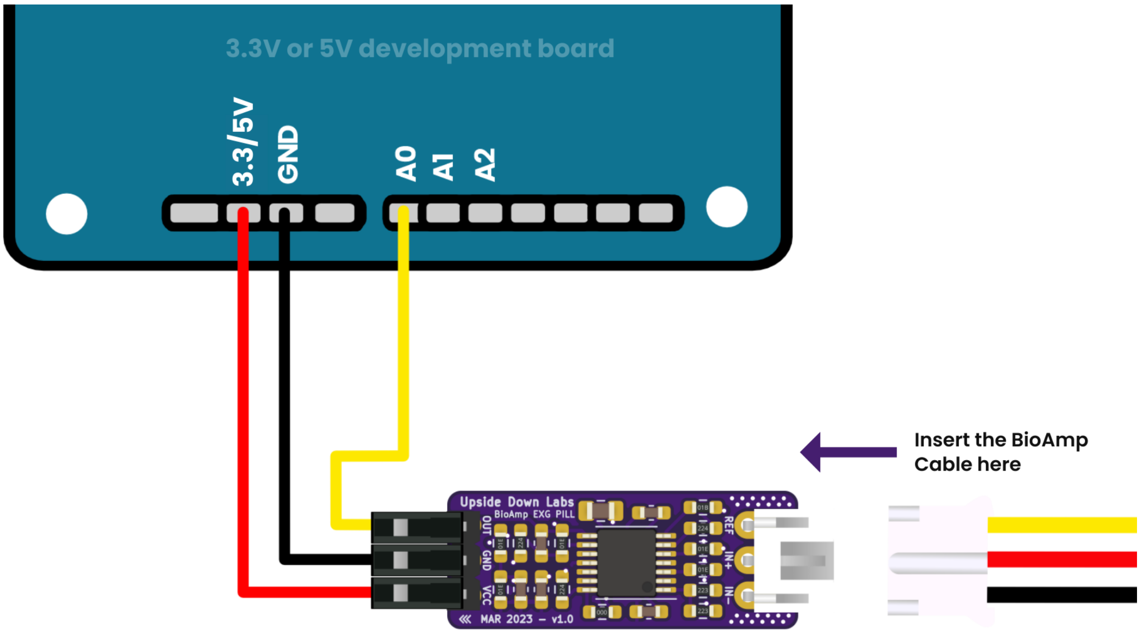


Fig. 4: *Connections with BioAmp Cable v3*

2.6.5 Step 5: Skin Preparation

Determine the target area and 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 Guide*.

2.6.6 Step 5: Electrode placement

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

1. Using Gel electrodes guide
2. *Assembling & using BioAmp Bands guide*

Once you have made the connections, return here to proceed to the next steps.

2.6.7 Step 6: Uploading the code

1. Connect the development board to your laptop using it's USB cable. Go to Chords Arduino Firmware github repository, scroll down to see a list of development boards compatible with Chords Software Suite. Copy the arduino sketch corresponding to your development board and paste it in Arduino IDE that you downloaded earlier.

    Link for the Github repo: Chords Arduino Firmware

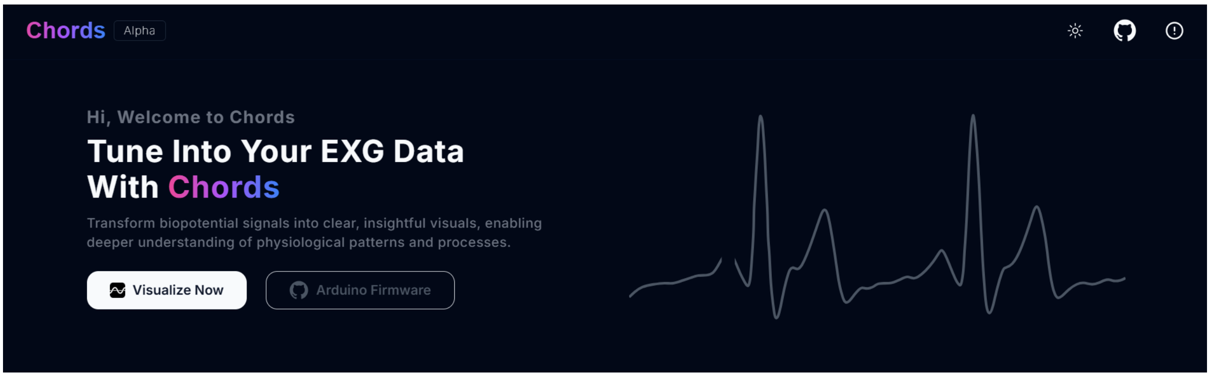
2. If you are using Arduino UNO R3/Arduino Nano/Arduino Mega/Maker Uno, you will have to uncomment the corresponding macro (eg. uncomment `#define BOARD_MAKER_UNO` when using Maker Uno) at the start of the code.
3. If you are using any other development board then skip step 2.
4. Now go to `tools > board` and select you board name. If the name doesn't appear, install the required libraries. In the same menu, select the COM port on which your board 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 click on the upload button.

Warning

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

2.6.8 Step 7: Setting up Chords Web

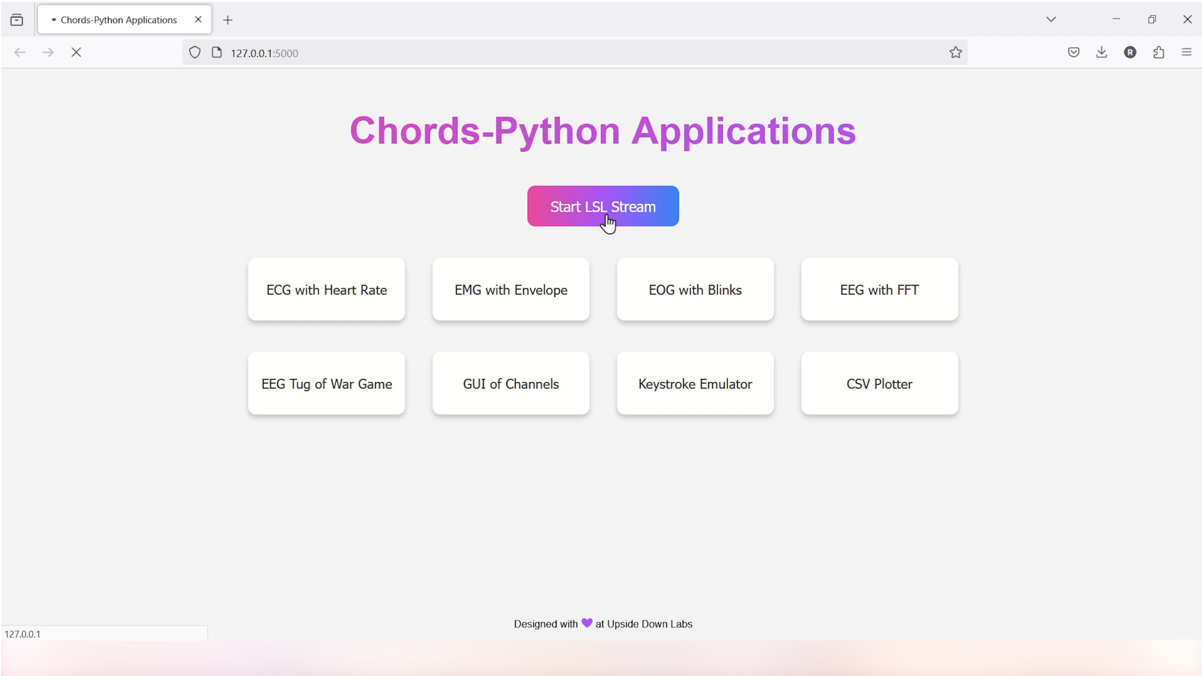
1. Visit chords.upsidedownlabs.tech.
2. Click on "Visualize now" button.



3. **At the bottom, you can see buttons to access various applications:**
    a. Chords Visualizer: Use this application for real-time data visualization, recording and data management, filter options, and multi-channel support.
    b. FFT Visualizer: Use this app to visualize filtered EEG signals in real-time, FFT graph, EEG frequency bands, and a beta candle to determine your focus.
    c. Serial Wizard: This interface provides real-time serial data visualization using serial plotter and monitor, optimised data rendering, baud rate selection and options to toggle between different modes.
4. Click on any of the button according to your requirement, select the COM port and click OK. You will be able to visualize your signals on the screen.

2.6.9 Step 8: Setting up Chords Python

Since you have uploaded the firmware already to your board, use our python script and follow the steps given in the Chords-Python documentation for LSL streaming, CSV data logging, verbose output with detailed statistics and error reporting. Not only that, you get a complete web interface to access various applications (like ECG with heart rate, EMG with envelope, GUI of channels, CSV plotter, etc.) that you can use to further analyse your signals and create HCI/BCI projects.



2.7 Glimpses of previous versions

The BioAmp EXG Pill can be used in a variety of ways, the YouTube video below shows a potential way of using `v0.7` of BioAmp EXG Pill.

https://youtu.be/-G3z9fvQnuw

A lot has improved in terms of interference rejection and flexibility from `v0.7` to `v1.0` of the BioAmp EXG Pill. The YouTube video below shows the ECG, EMG, EOG, and EEG recording using `v1.0b` of device.

https://youtu.be/z9-B9bHWuhg

2.8 Real-world Applications

BioAmp EXG Pill is perfect for researchers, makers, and hobbyists looking for novel ways to sample biopotential data. It can be used for a wide variety of interesting biosensing projects, including:

- AI-assisted detection of congestive heart failure using CNN (ECG)
- Heart-rate variability calculation to detect heart ailments (ECG)
- Prosthetic arm (servo) control (EMG)
- Controlling a 3DOF robotic arm (EMG)
- Real-time game controllers (EOG)
- Blink detection (EOG)

- Capturing photos with a blink of an eye (EOG) and many more examples.

2.9 Project ideas & tutorials

You can find step-by-step tutorials for various HCI/BCI projects on our Instructables.

Below are some project ideas that you can try making at your home.

1. Controlling video game using brainwaves (EEG)
2. Visualising electrical impulses from eyes (EOG)
3. Recording EEG from visual cortex part of brain
4. Recording EEG from prefrontal cortex part of brain
5. Eye blink detection
6. Creating a drowsiness detector
7. Record publication-grade ECG
8. Measuring heart rate
9. Detecting heart beats
10. Record publication-grade EMG
11. Detecting up and down movement of eyes

These are some of the project ideas but the possibilities are endless. So create your own Human Computer Interface (HCI) and Brain Computer Interface (BCI) projects and share them with us at contact@upsidedownlabs.tech.

CHAPTER

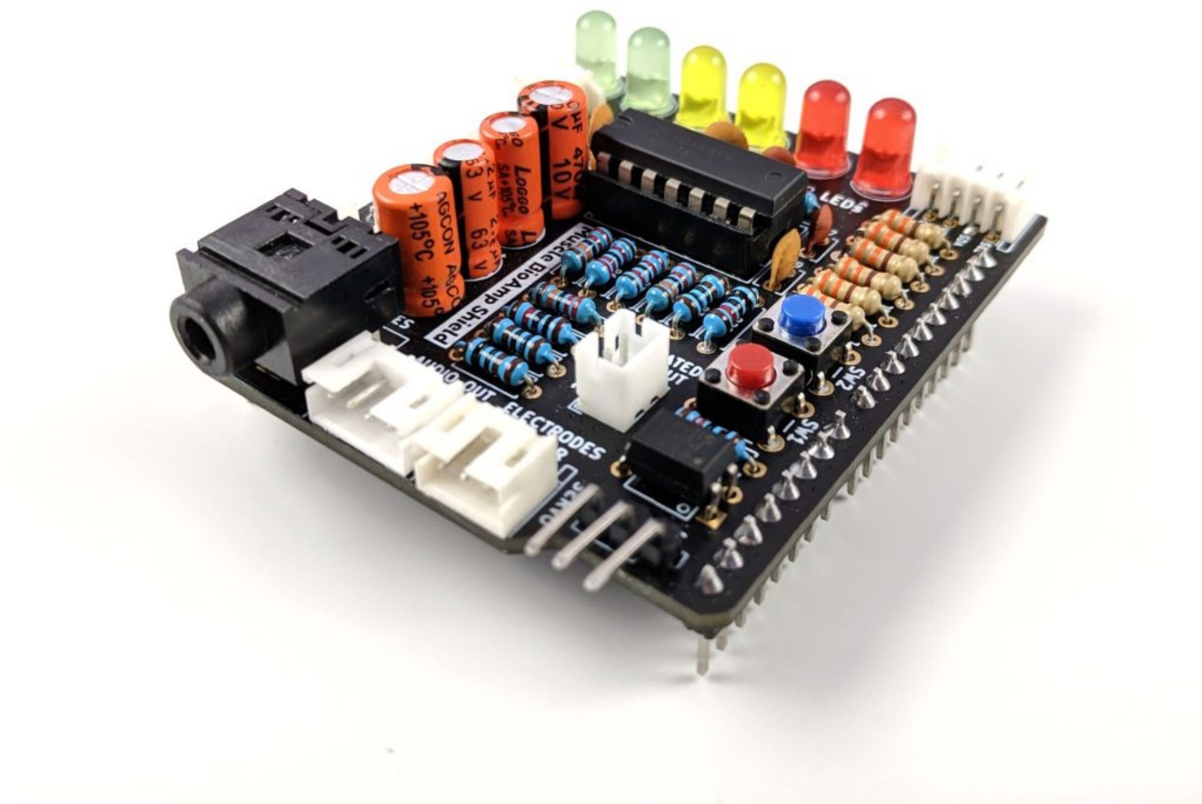
THREE

MUSCLE BIOAMP SHIELD

v0.3

3.1 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).



3.2 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

3.3 Hardware

Images below shows a quick overview of the hardware design.

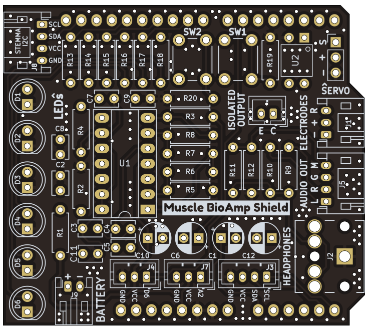


Fig. 1: *PCB Front*

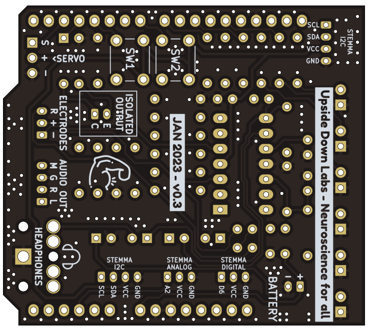


Fig. 2: *PCB Back*

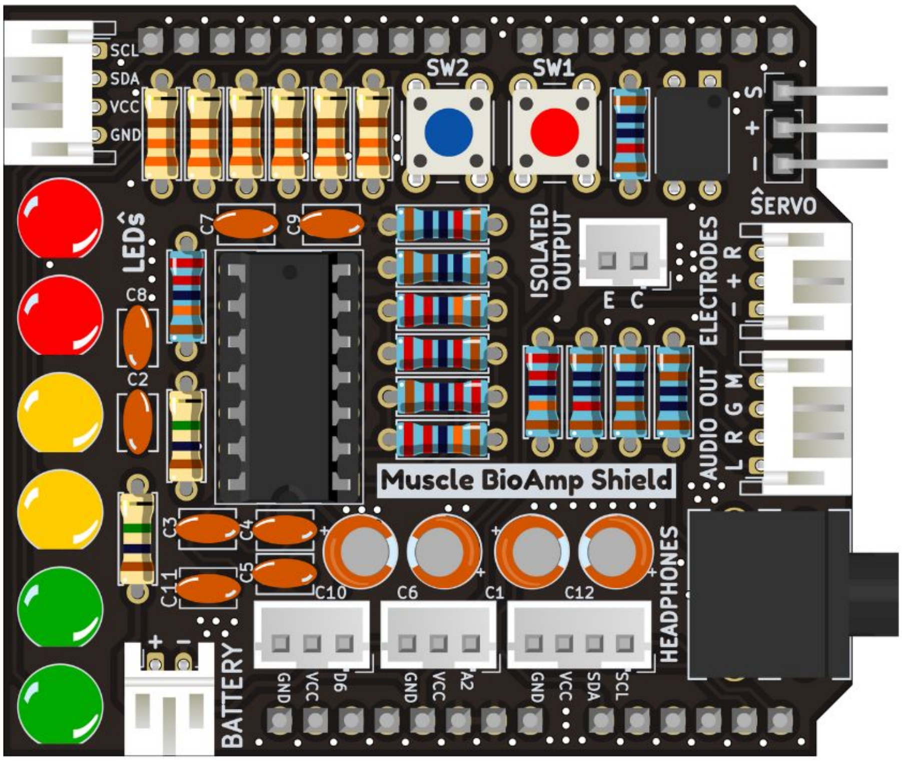


Fig. 3: *Assembled PCB*

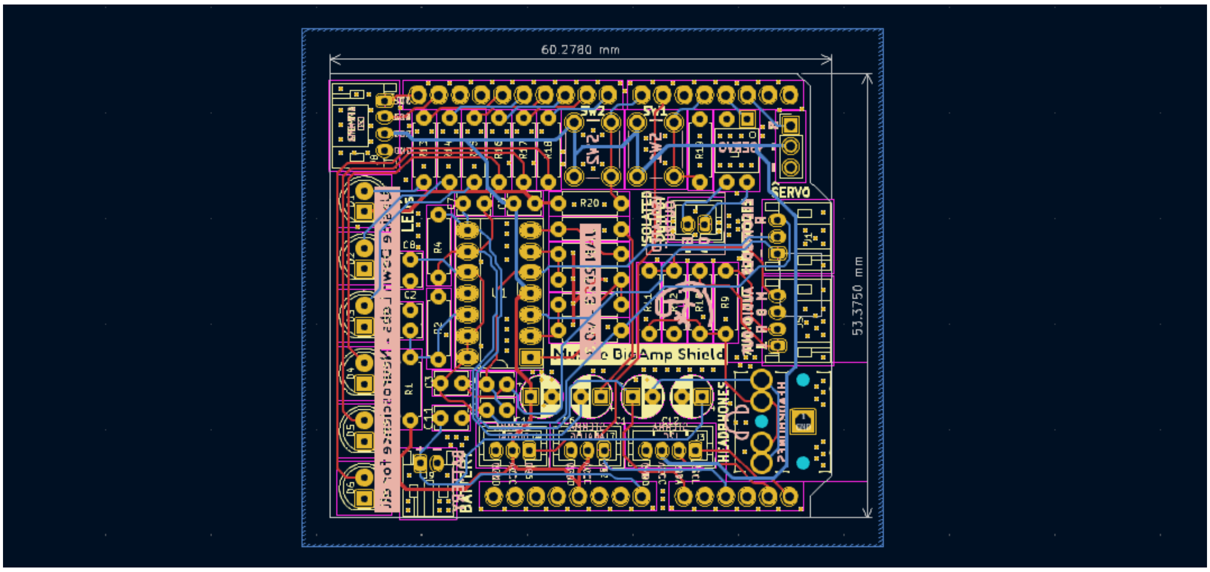


Fig. 4: *PCB Layout*

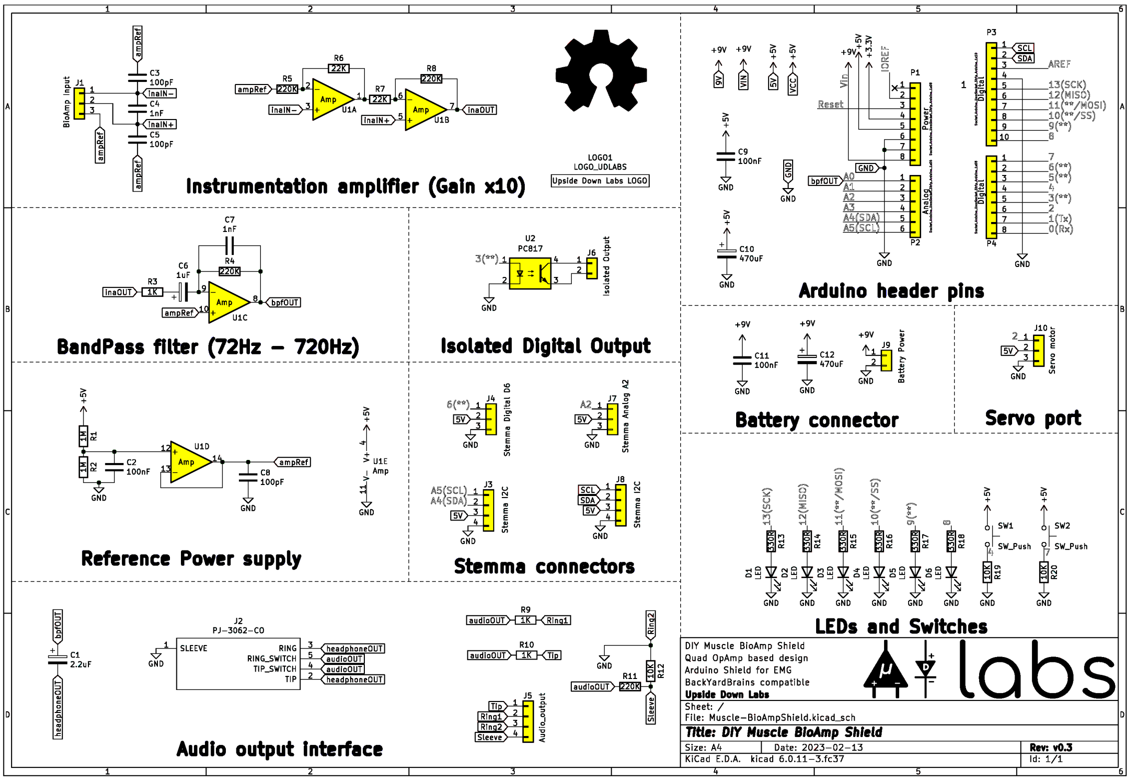


Fig. 5: *Schematic Diagram*

3.4 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.

Click on the link below to see the unboxing of the kit:

https://youtu.be/w8yw12SUe6Q

3.5 Software requirements

To use Muscle BioAmp Shield, you will need the softwares mentioned below. Instructions on how to use them are provided later in the guide.

- Arduino IDE (Download this to upload Chords arduino firmware to your development board)
- Chords Web (Use this open-source web application to visualize your biopotential signals)
- Visual Studio Code (or any other Code editor of your choice)
- Python (To run Chords-Python script)
- Chords Python (Use this open-source python script designed to record and visualize biopotential signals)

Note

1. The Chords Arduino firmware is identical for both Chords Web and Chords Python, so you only need to upload the code once, and you're all set.

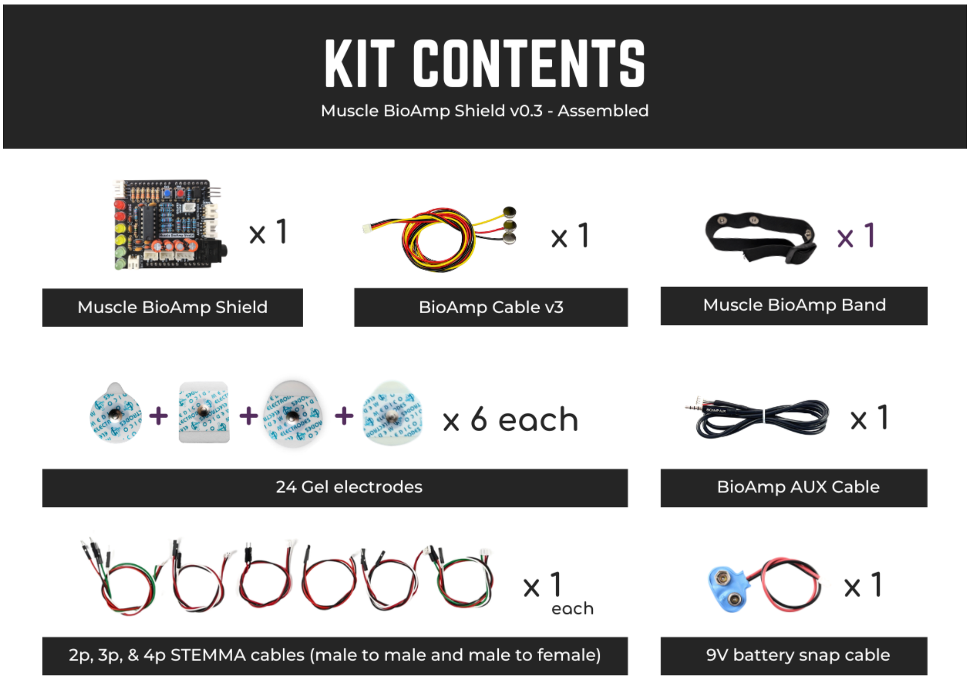


Fig. 6: *Assembled Muscle BioAmp Shield kit content*

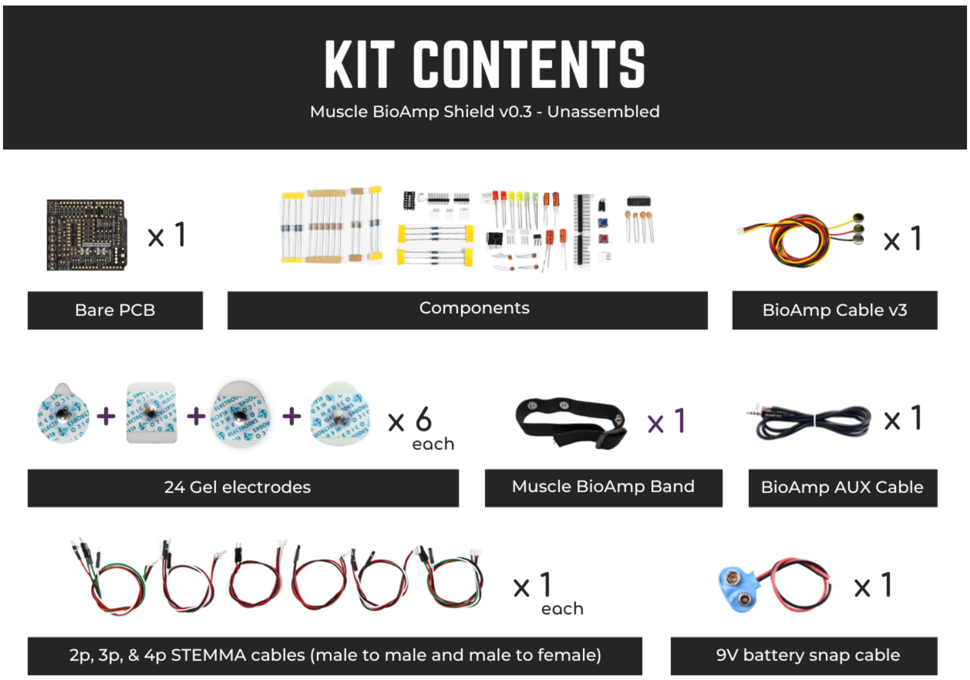


Fig. 7: *Unassembled Muscle BioAmp Shield kit content*

2. You can choose either Chords Web or Chords Python to record and visualize your biopotential signals based on your needs. If you're curious, you can try both one at a time.

3.6 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.

Note

Follow the highlighted yellow shapes to assemble your shield!

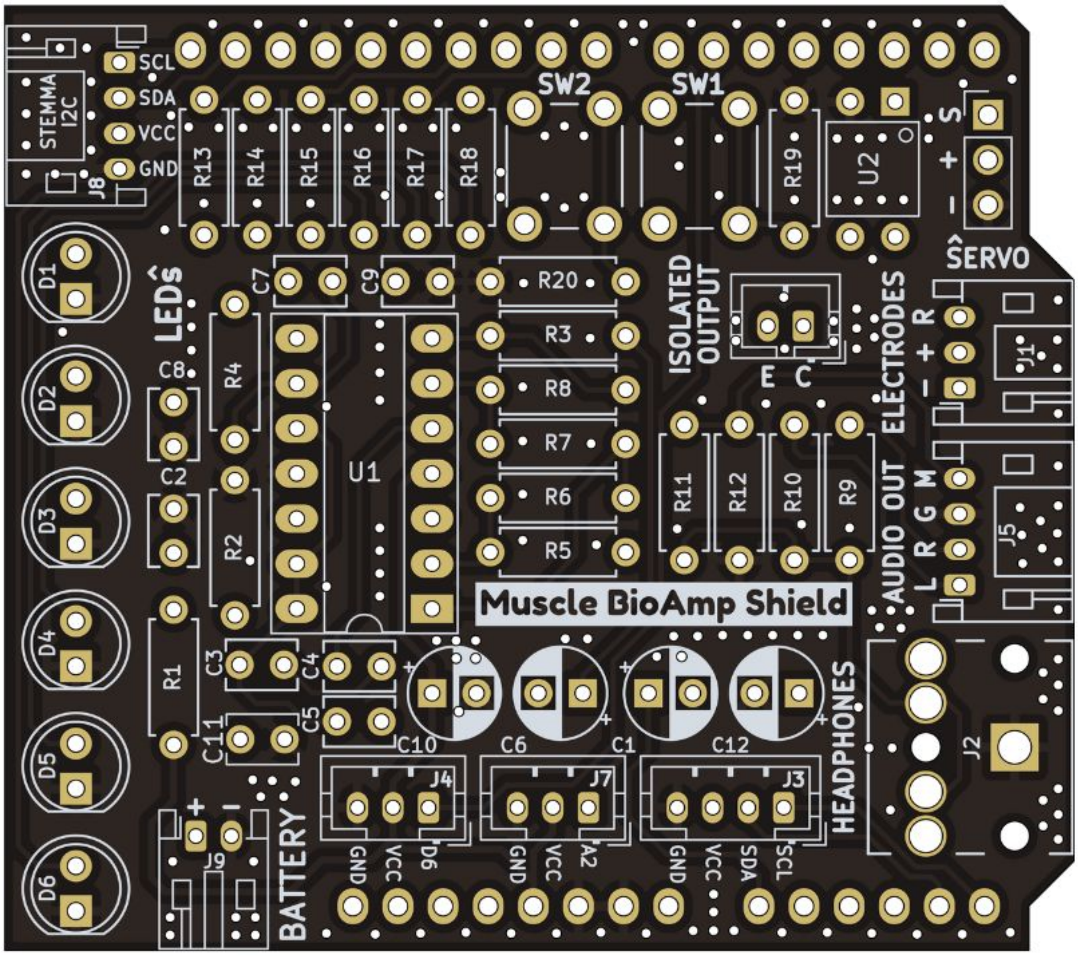


Fig. 8: **Step 1 - Bare Board**

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

https://youtu.be/dcuCihh3yn4

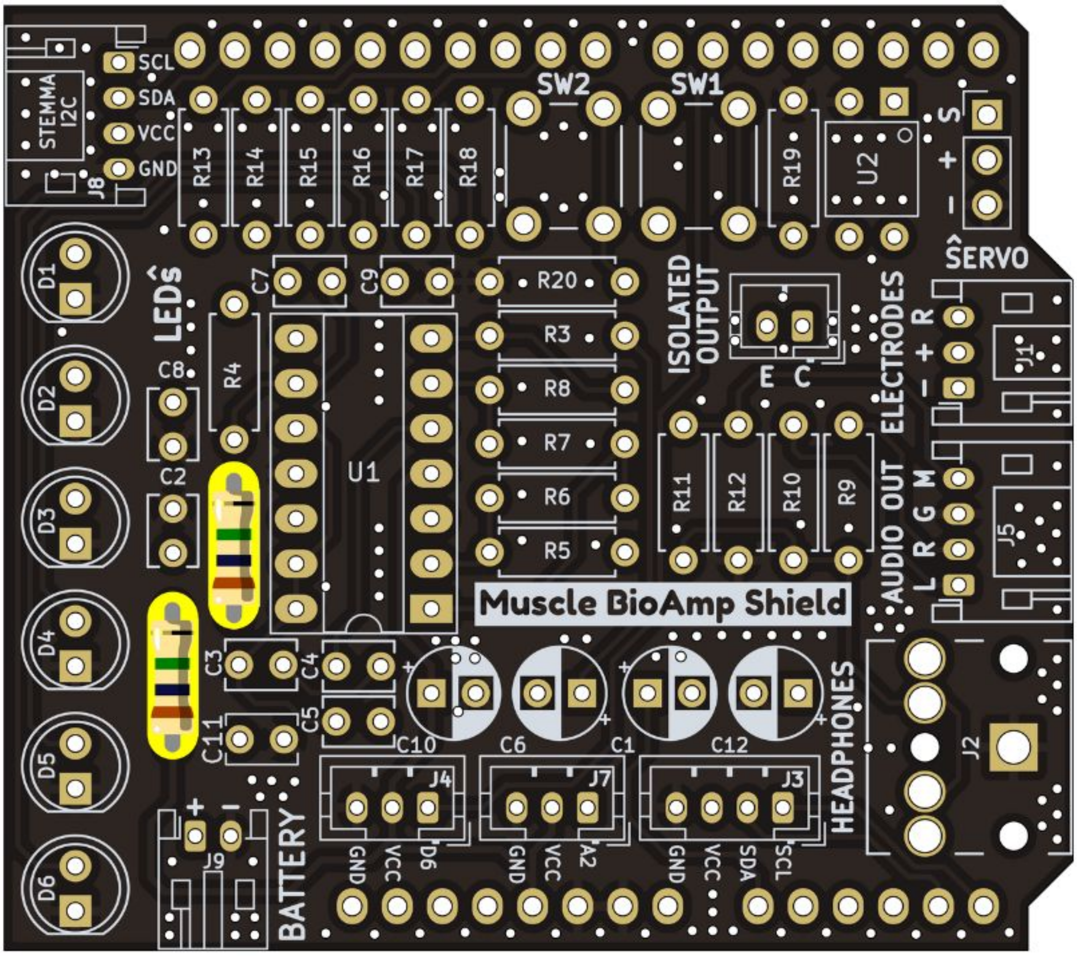


Fig. 9: **Step 2 - 1M Resistors**

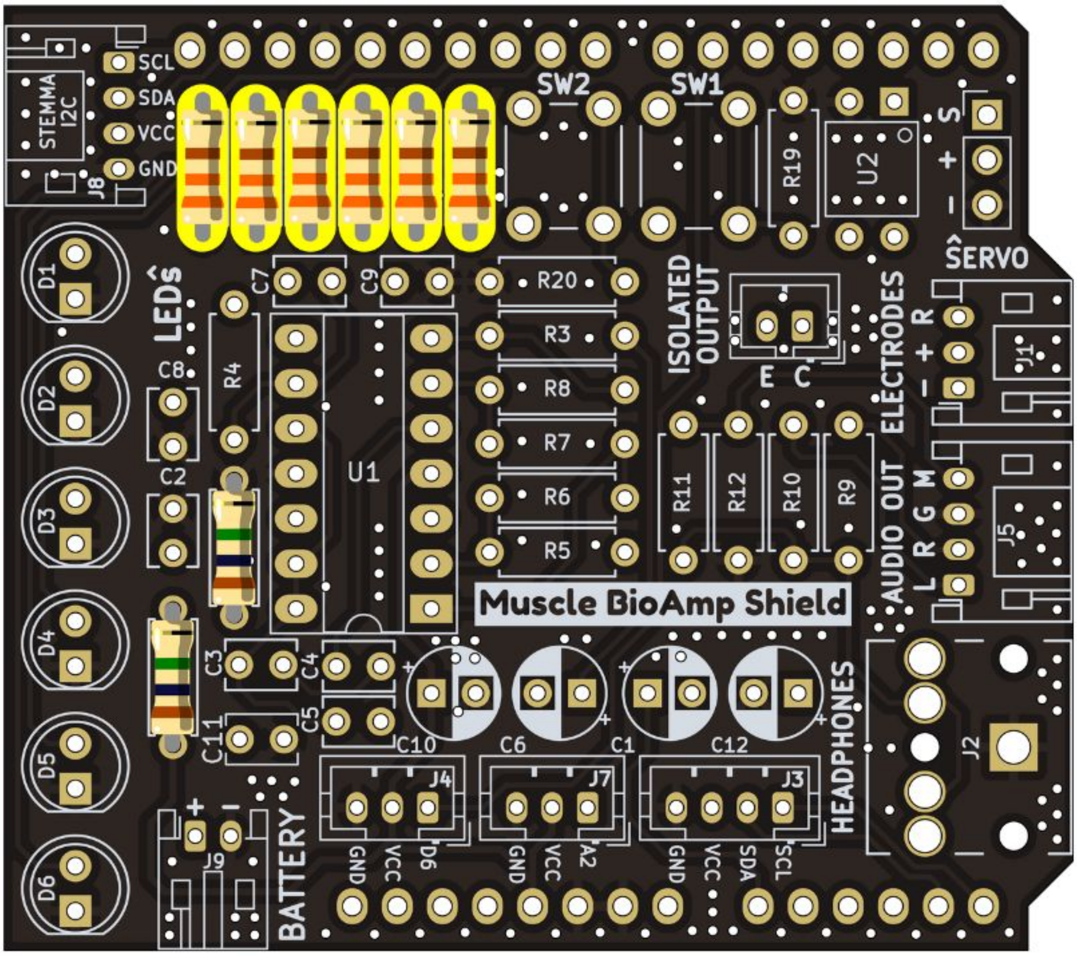


Fig. 10: **Step 3 - 330R Resistors**

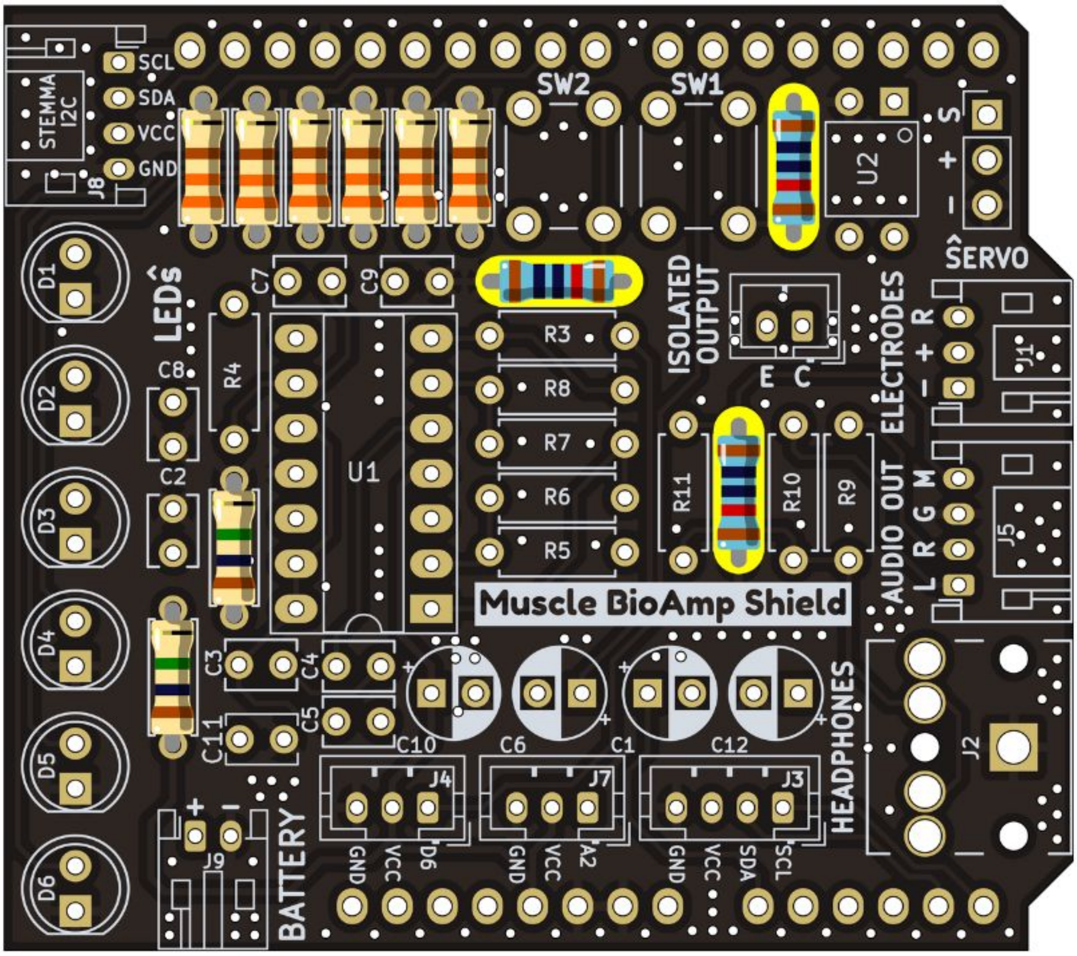


Fig. 11: **Step 4 - 10K Resistors**

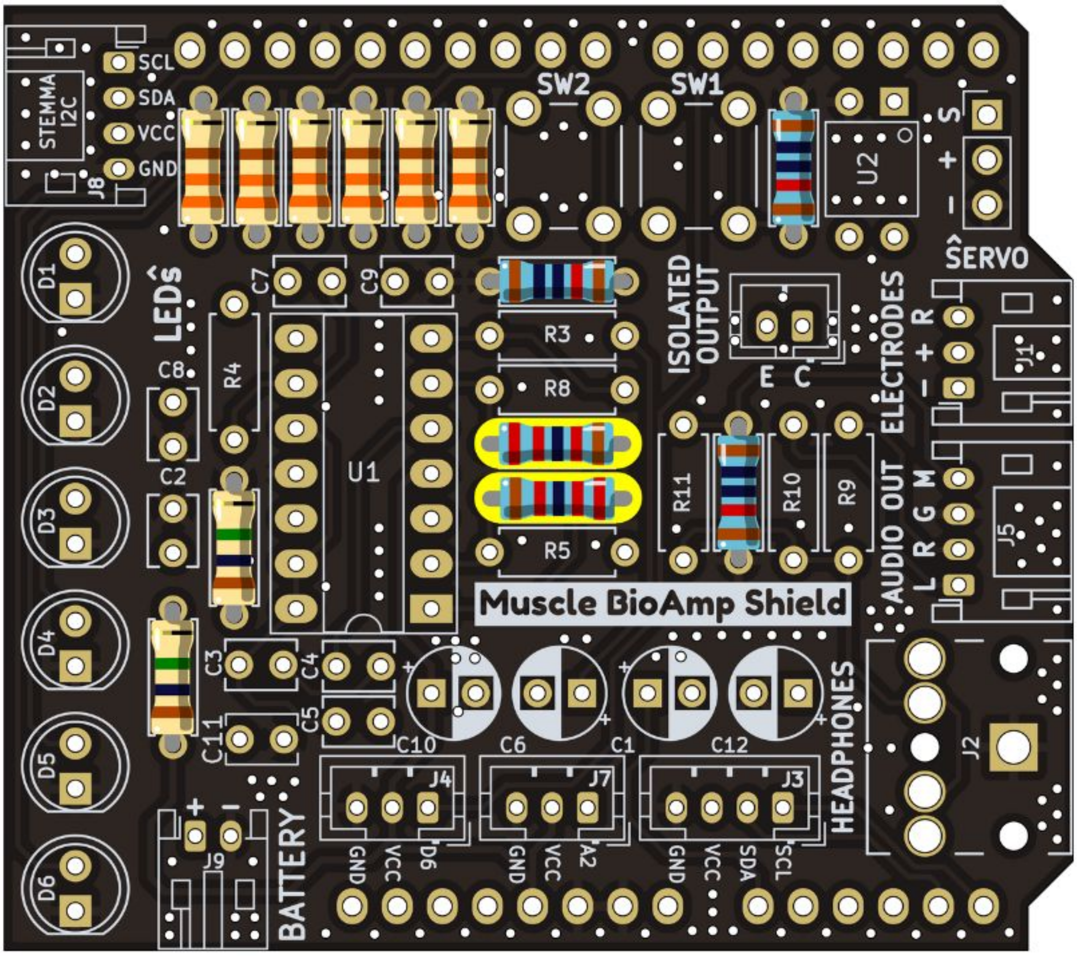


Fig. 12: **Step 5 - 22K Resistors**

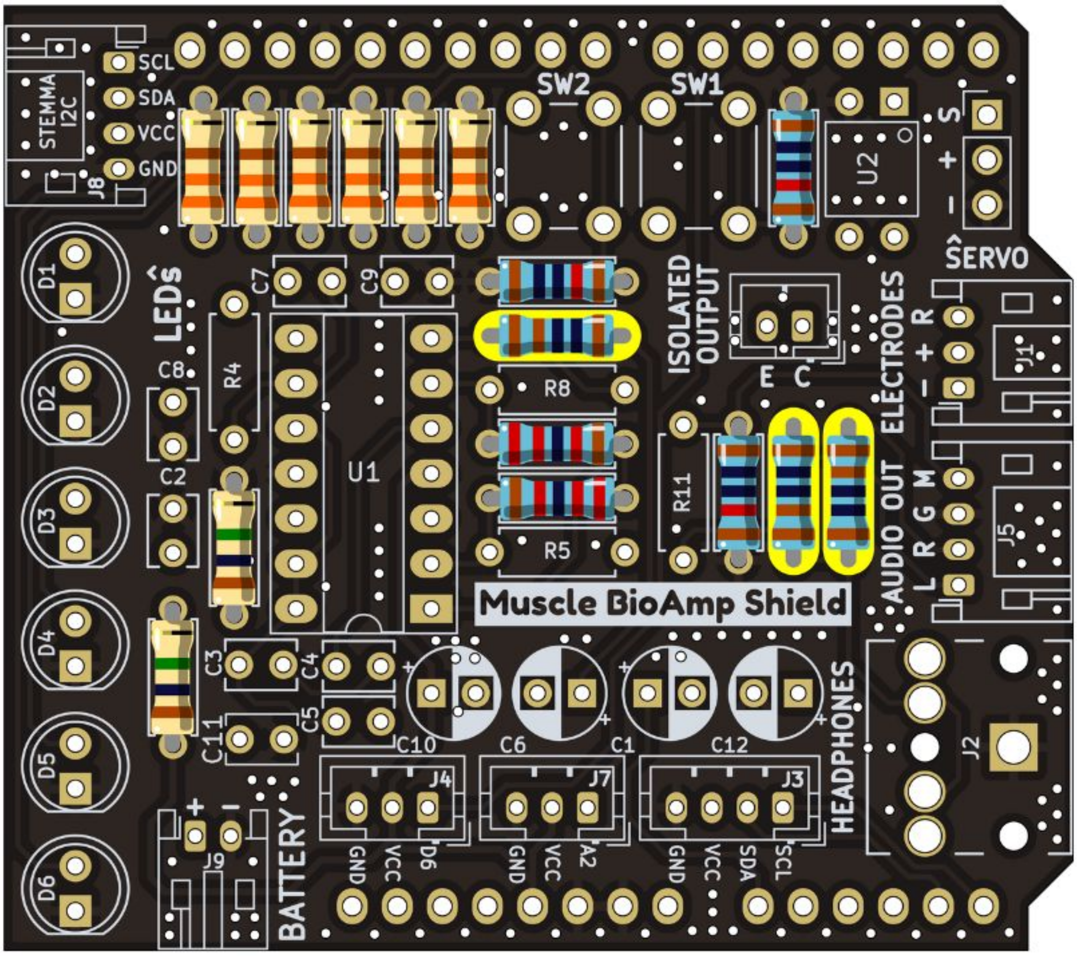


Fig. 13: **Step 6 - 1K Resistors**

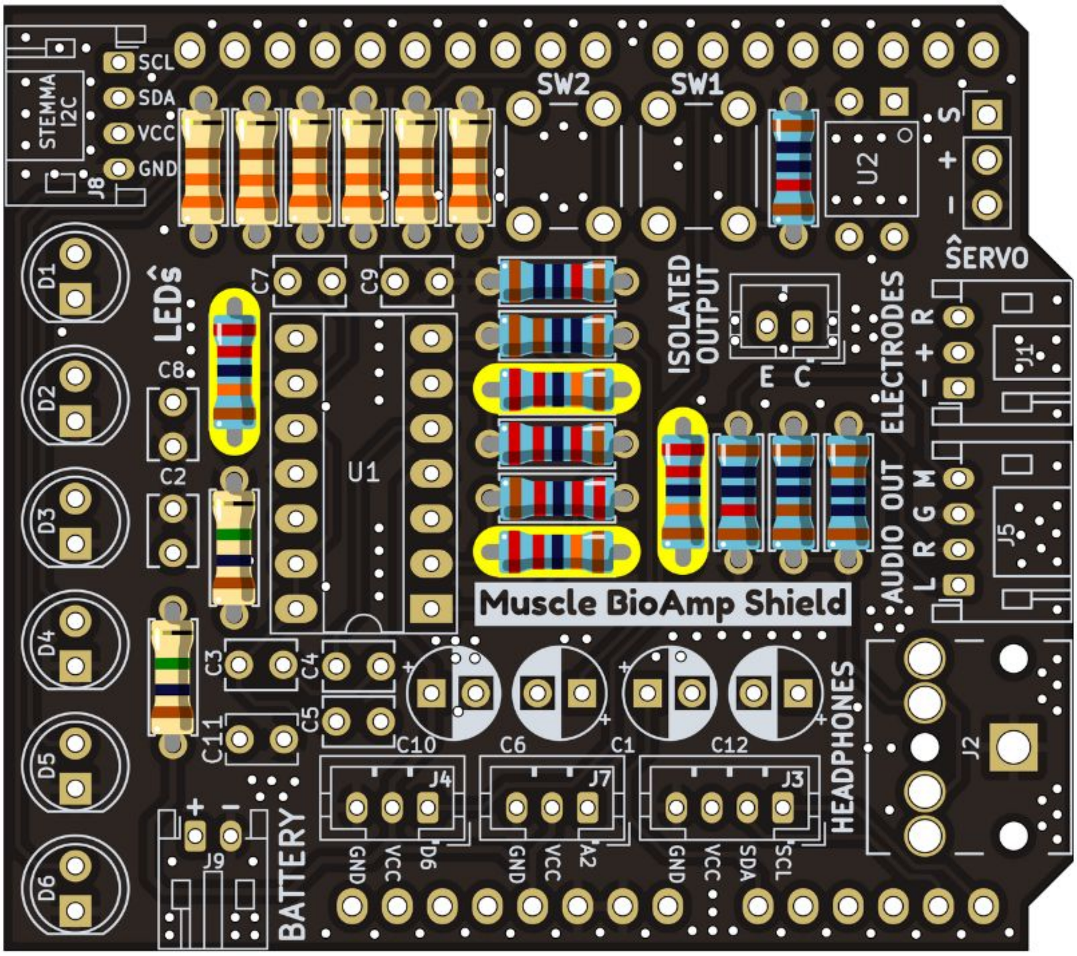


Fig. 14: **Step 7 - 220K Resistors**

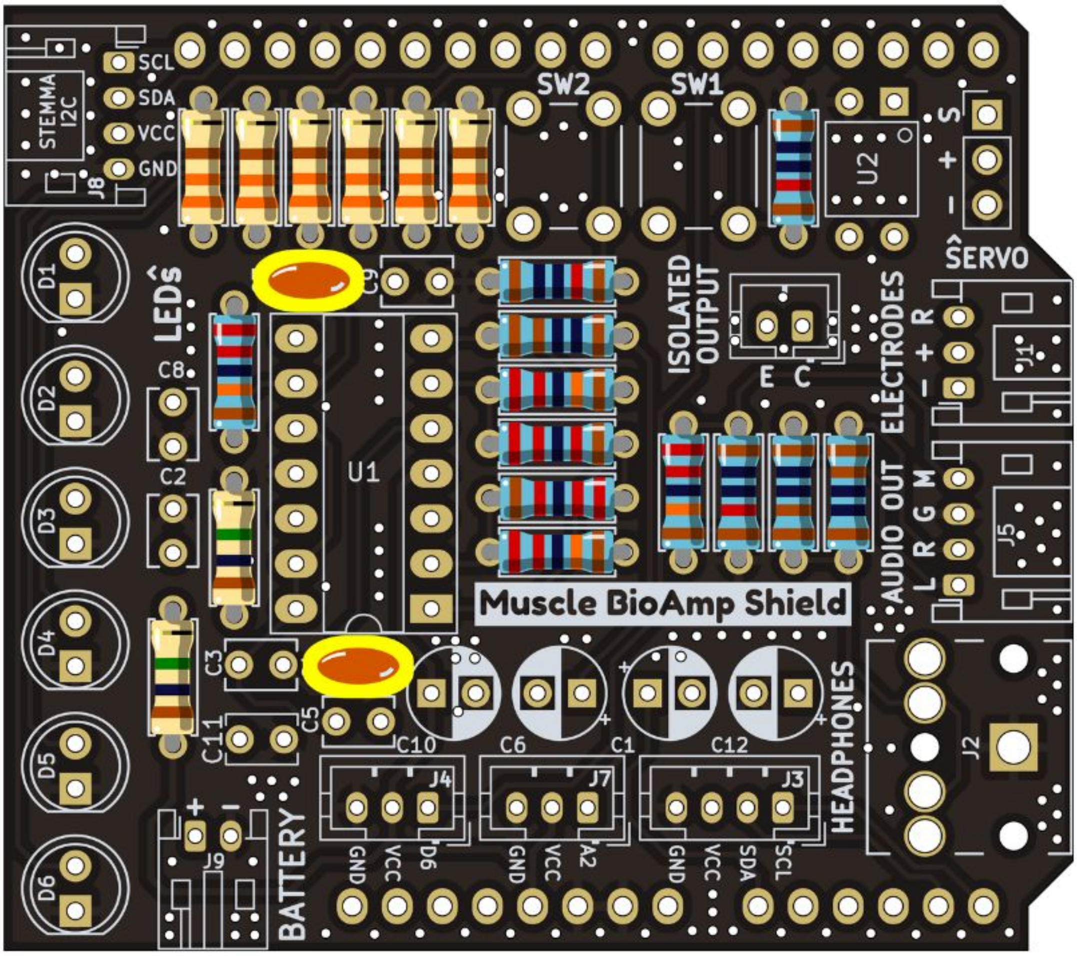


Fig. 15: **Step 8 - 1nF Capacitors**

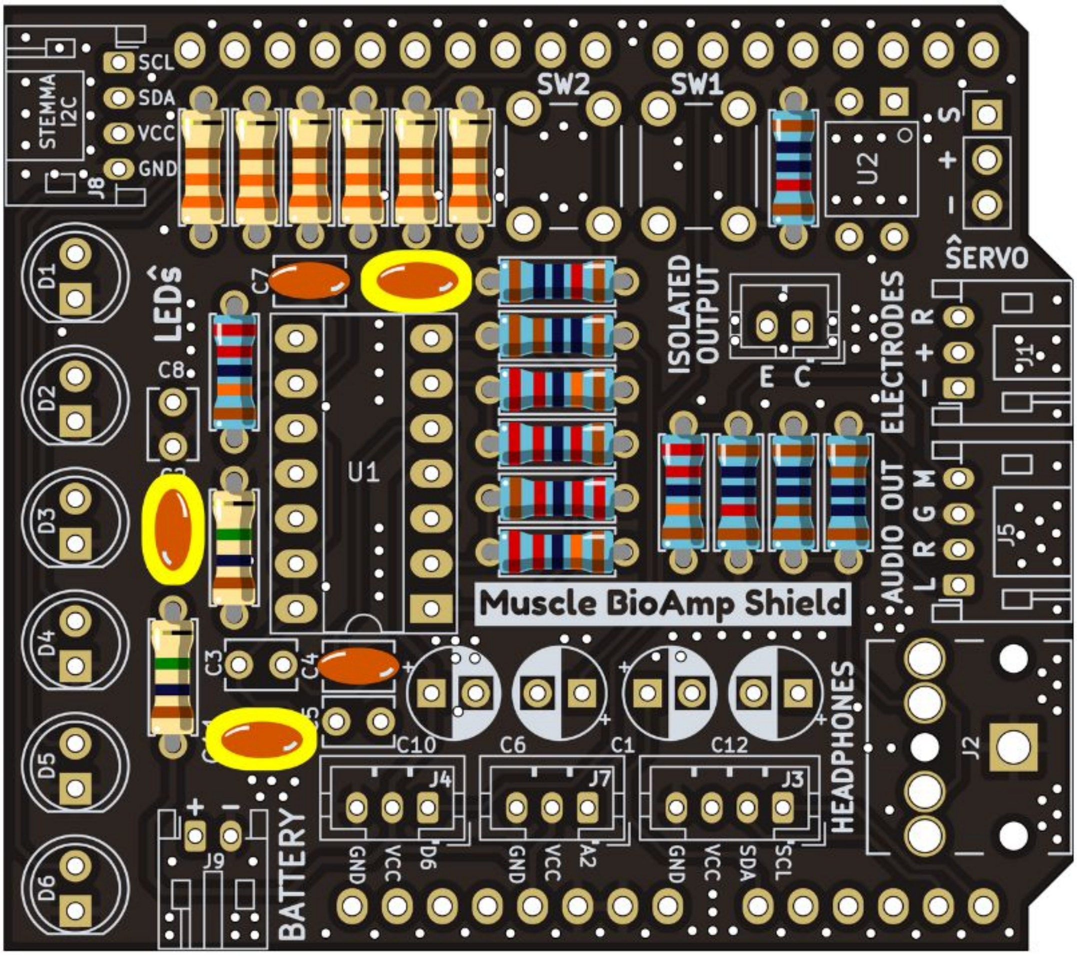


Fig. 16: **Step 9 - 100nF Capacitors**

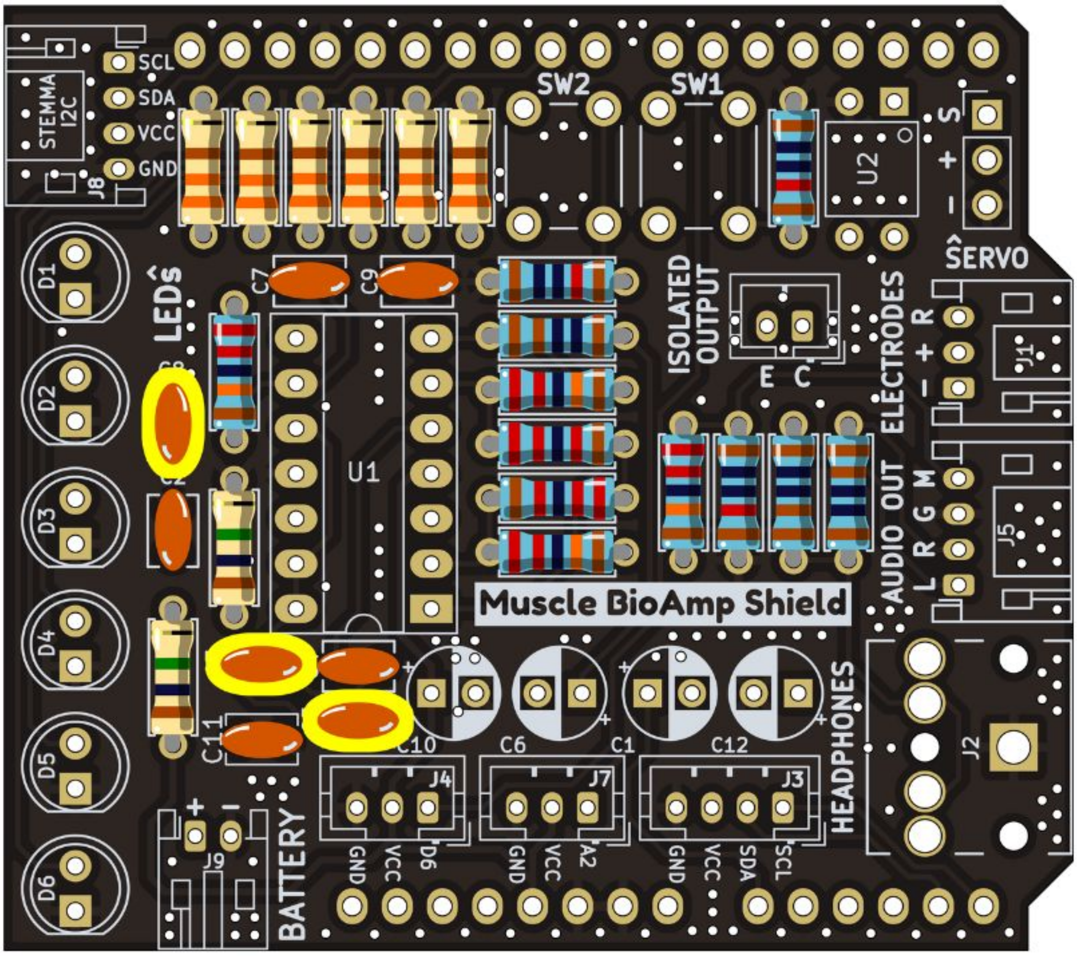


Fig. 17: **Step 10 - 100pF Capacitors**

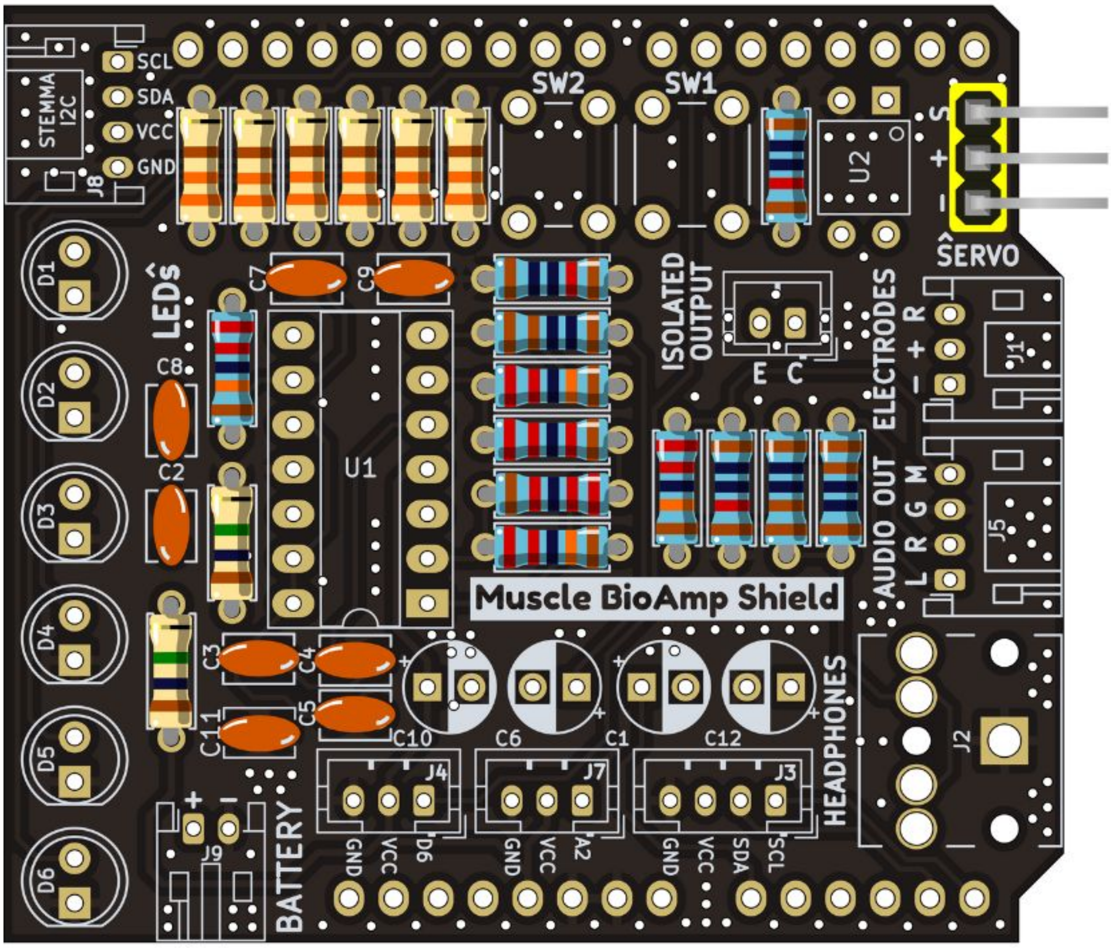


Fig. 18: **Step 11 - Angled Header Pins**

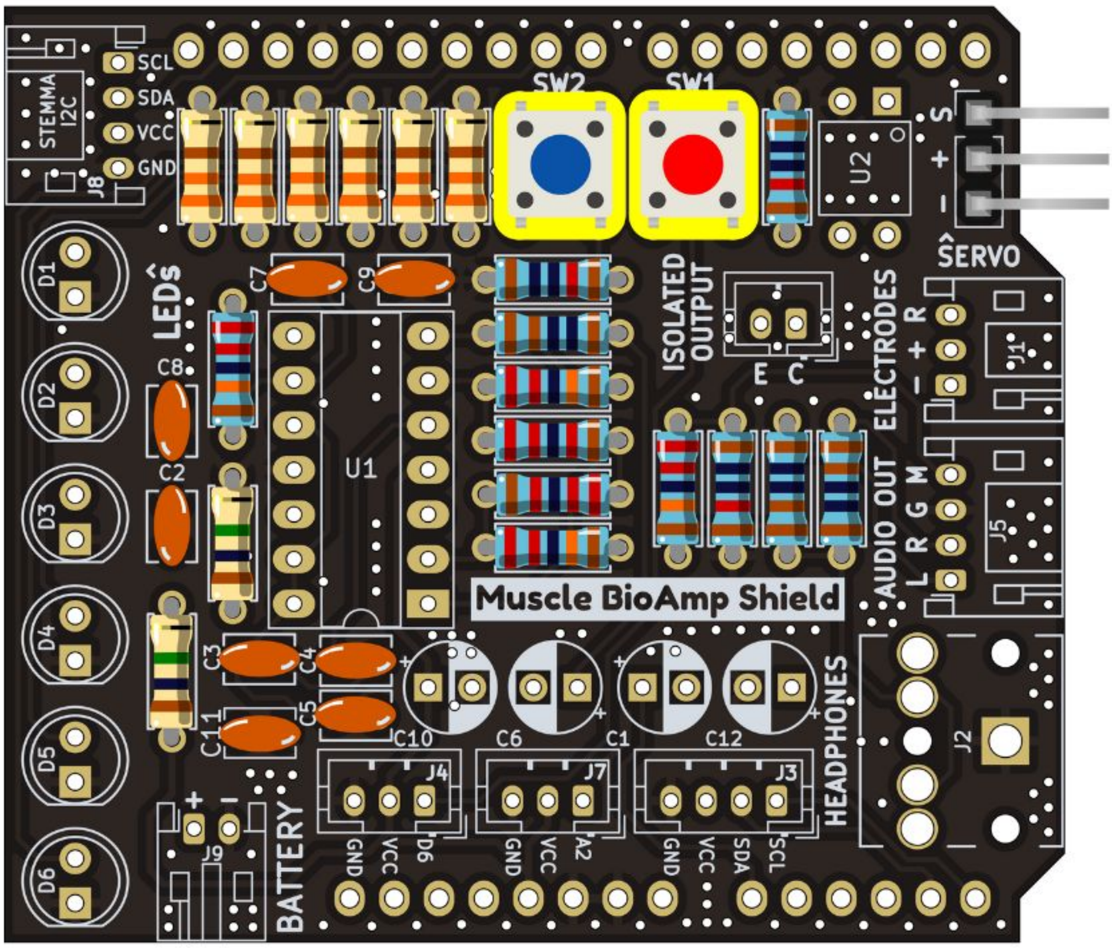


Fig. 19: **Step 12 - 5x5mm Buttons**

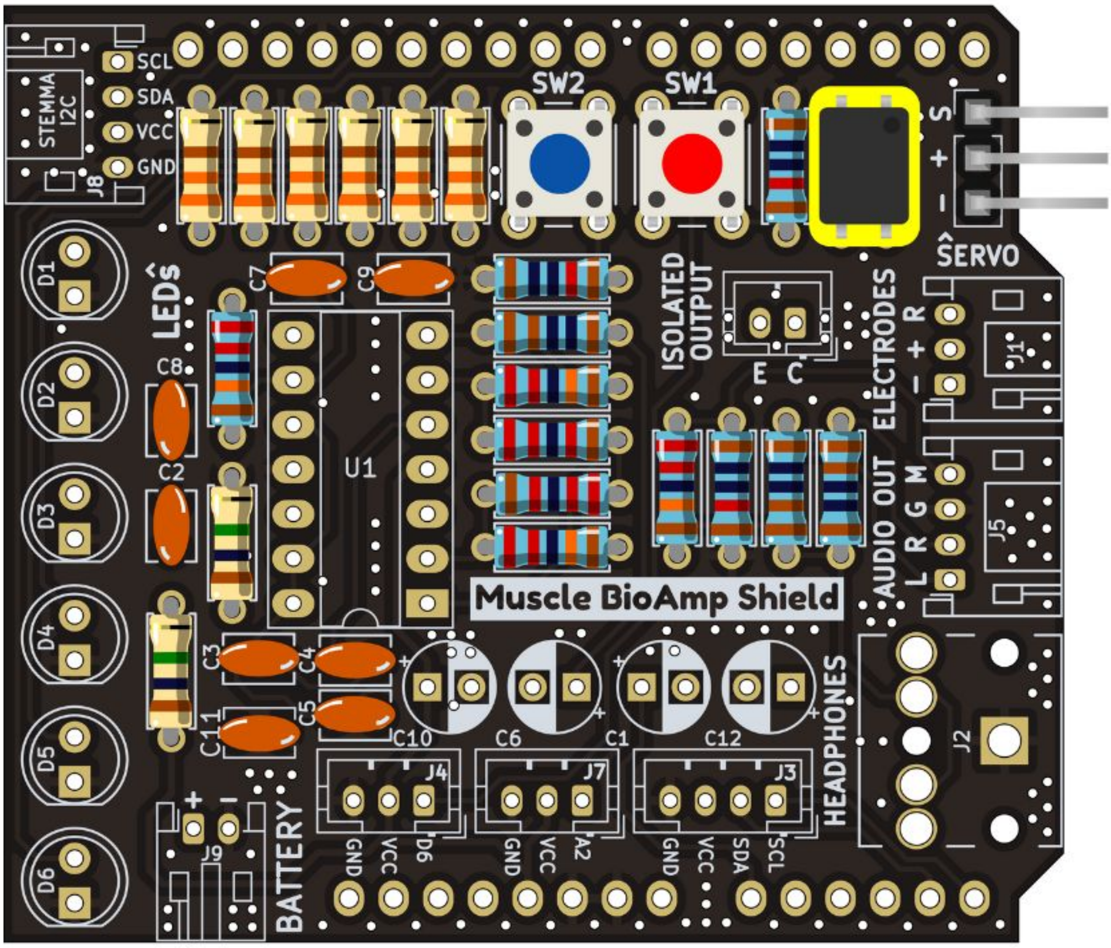


Fig. 20: **Step 13 - OptoIsolator**

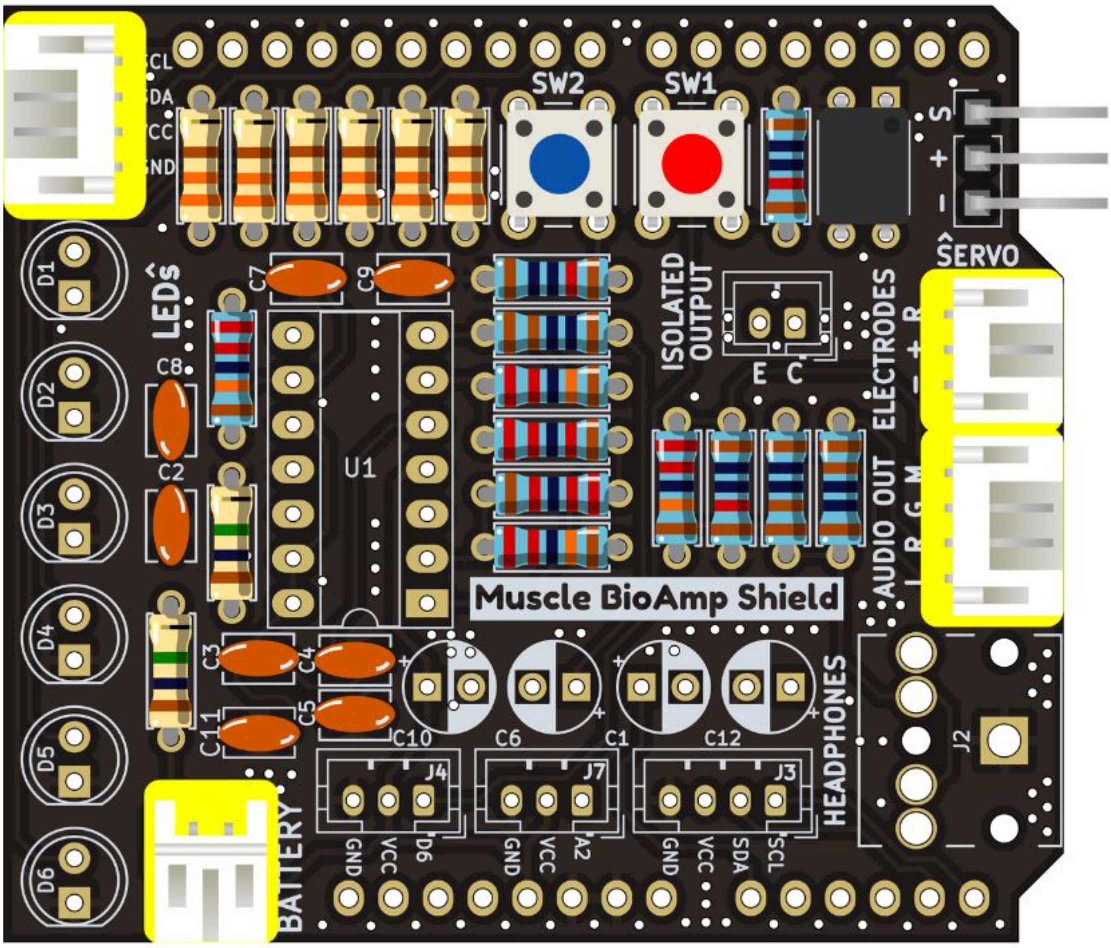


Fig. 21: **Step 14 - JST PH Angled Connectors**

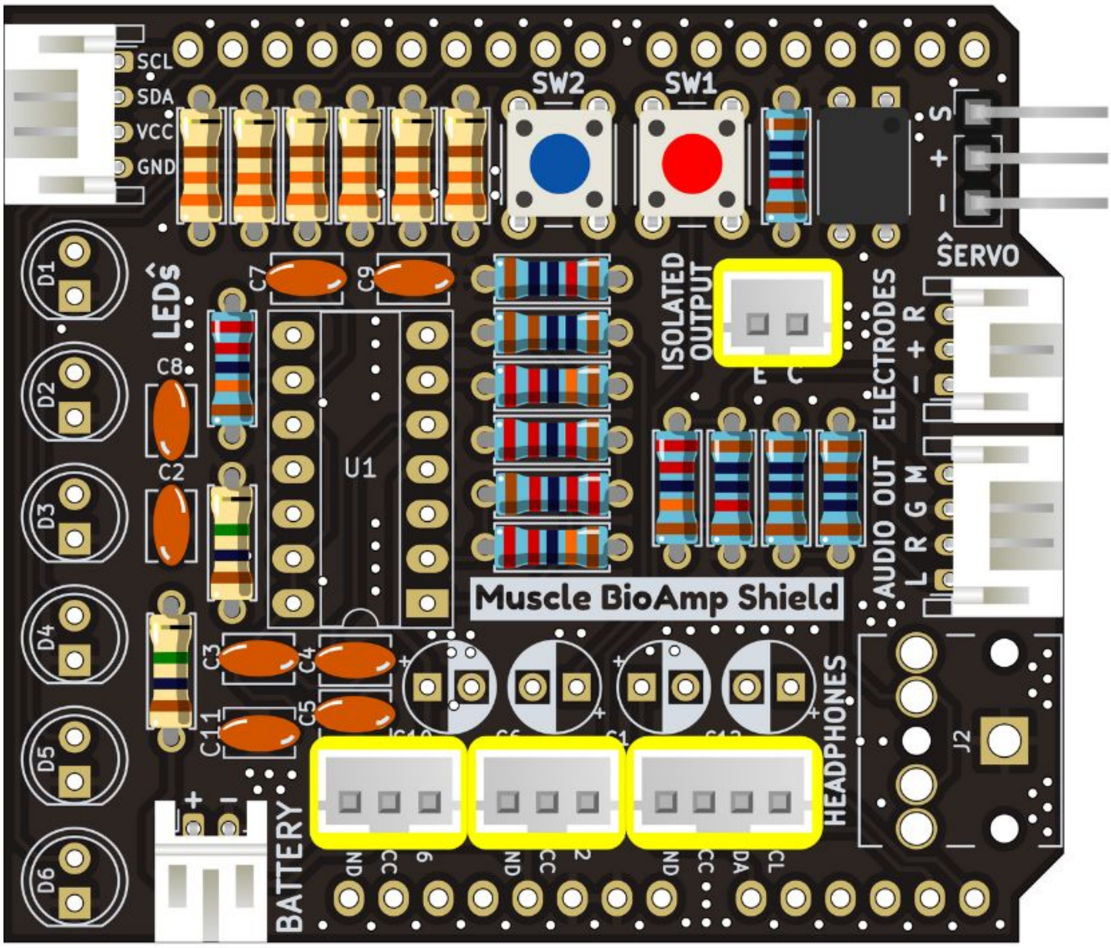


Fig. 22: **Step 15 - JST PH Straight Connectors**

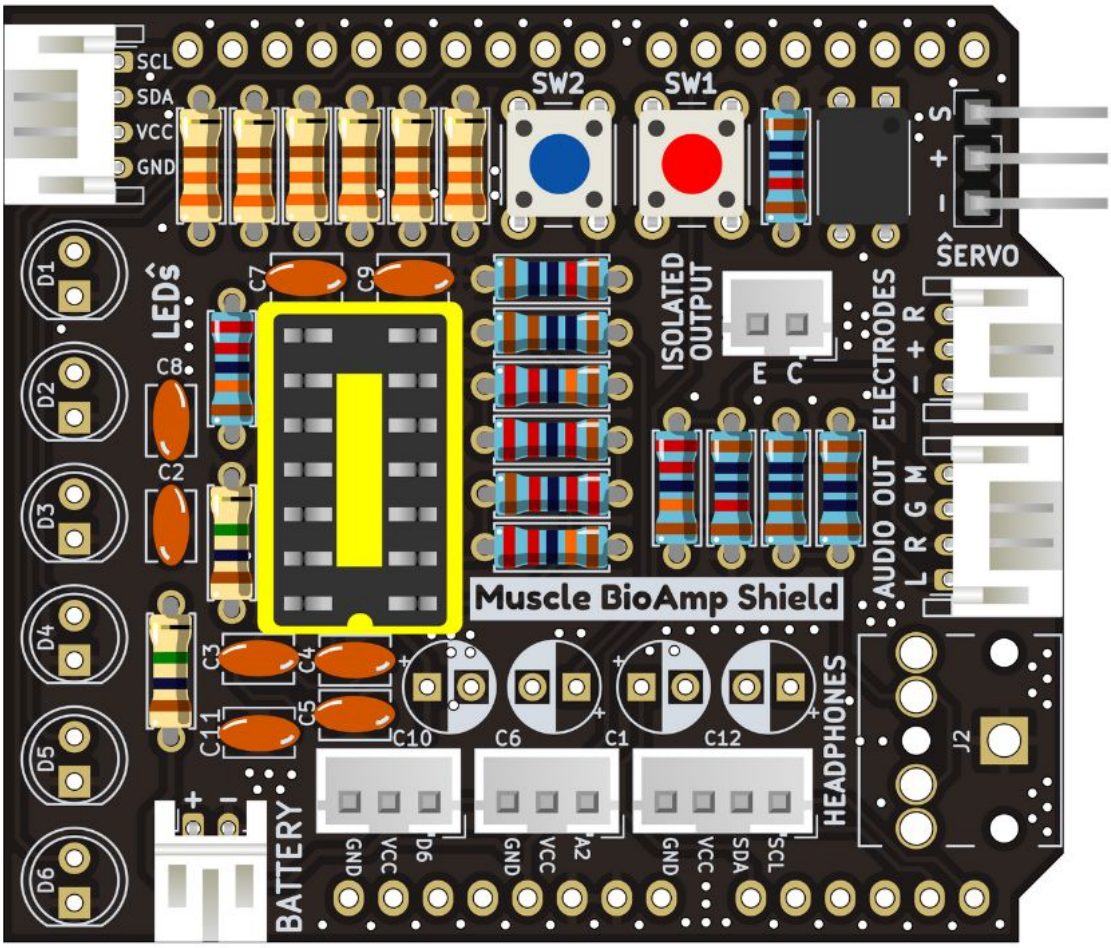


Fig. 23: **Step 16 - IC Socket**

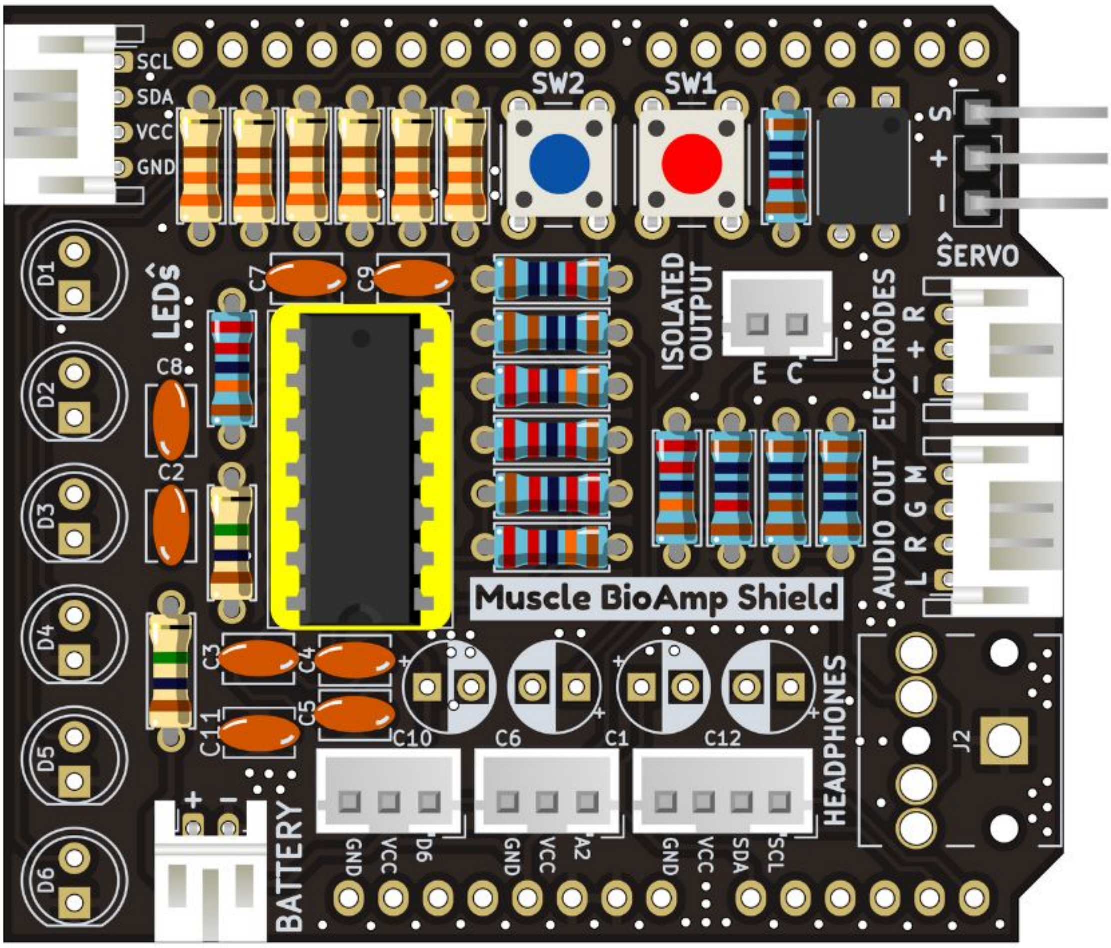


Fig. 24: **Step 17 - IC**

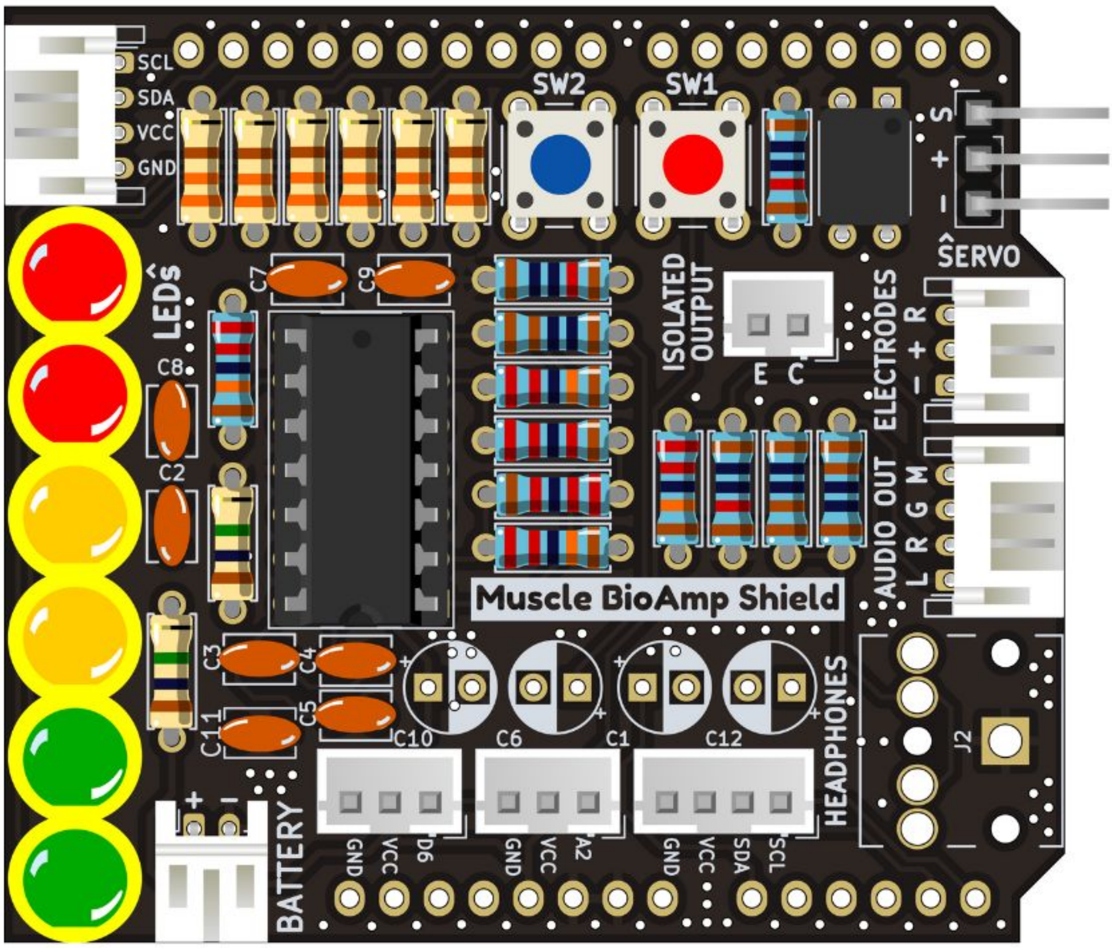


Fig. 25: **Step 18 - LEDs**

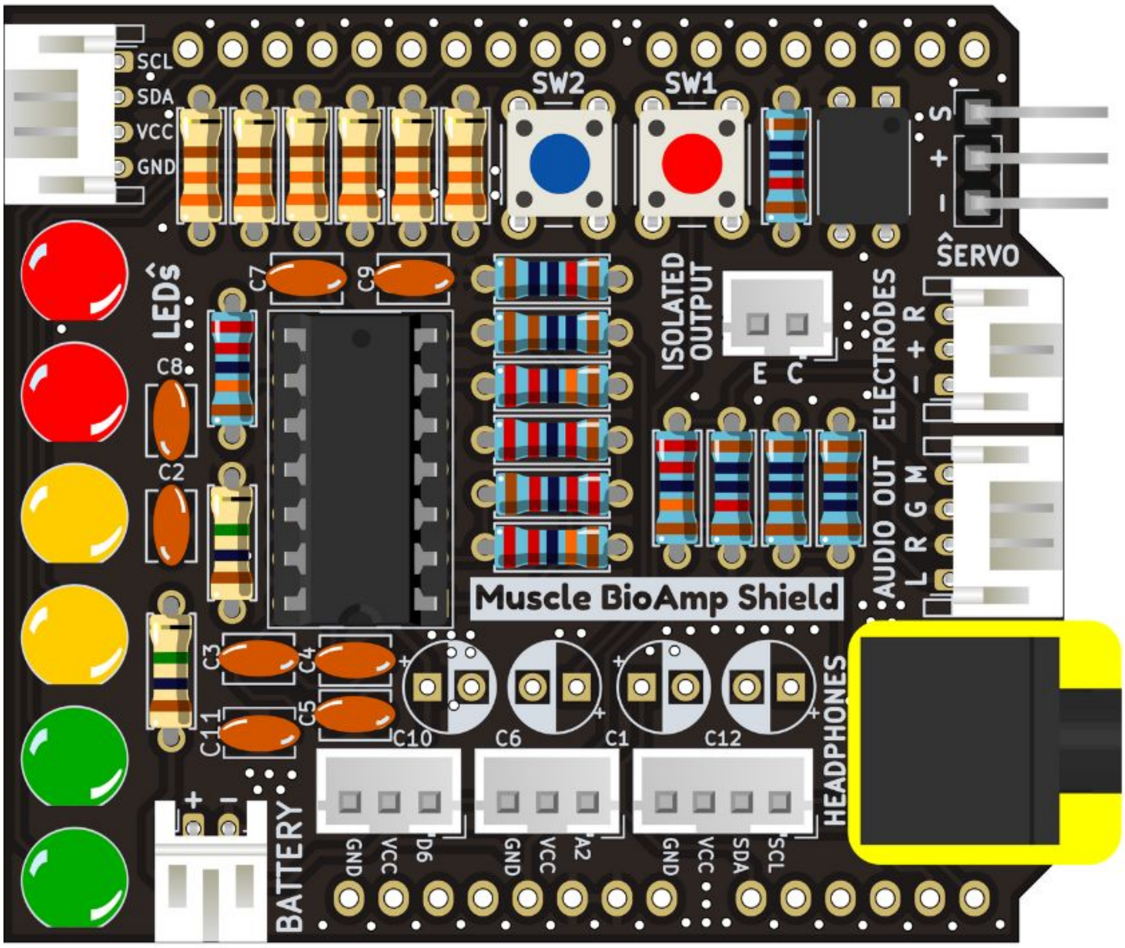


Fig. 26: **Step 19 - 3.5mm Headphone Jack**

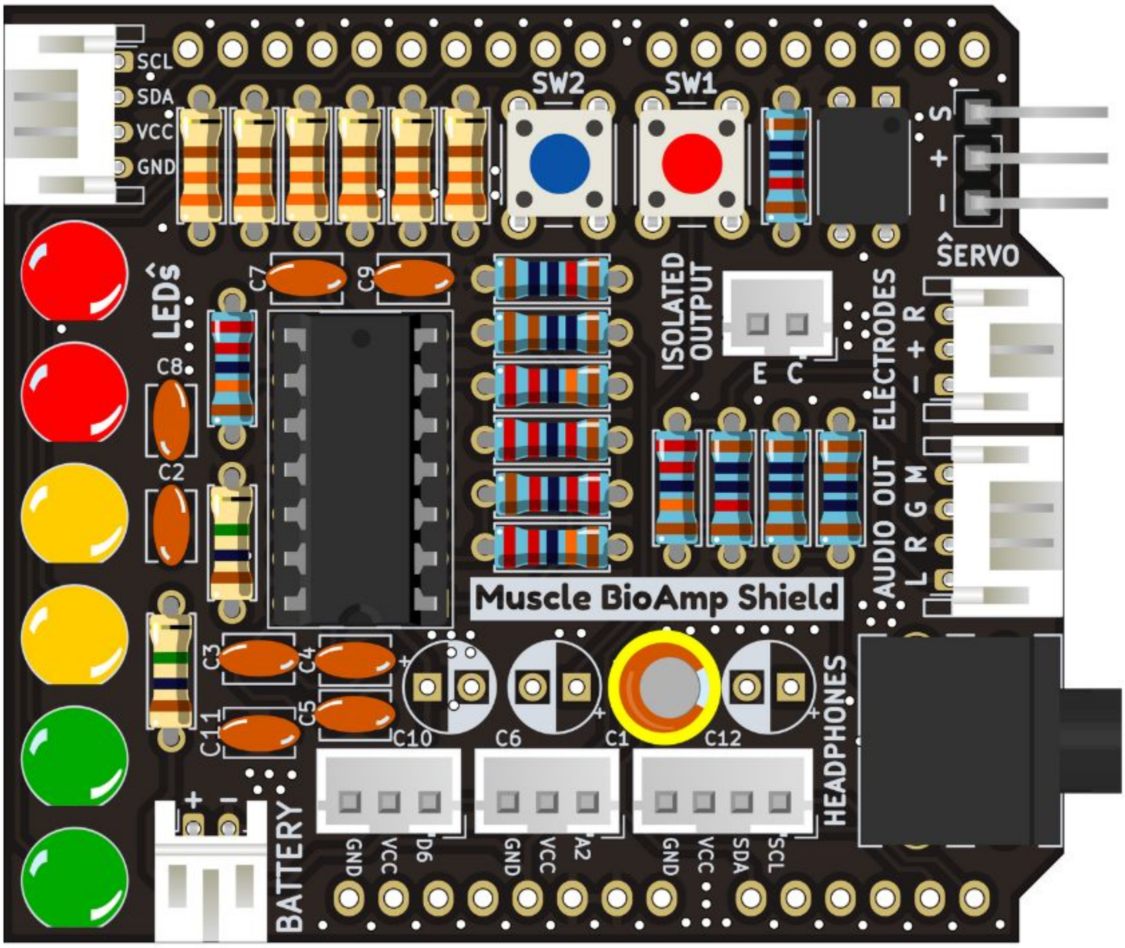


Fig. 27: **Step 20 - 2.2uF Capacitor**

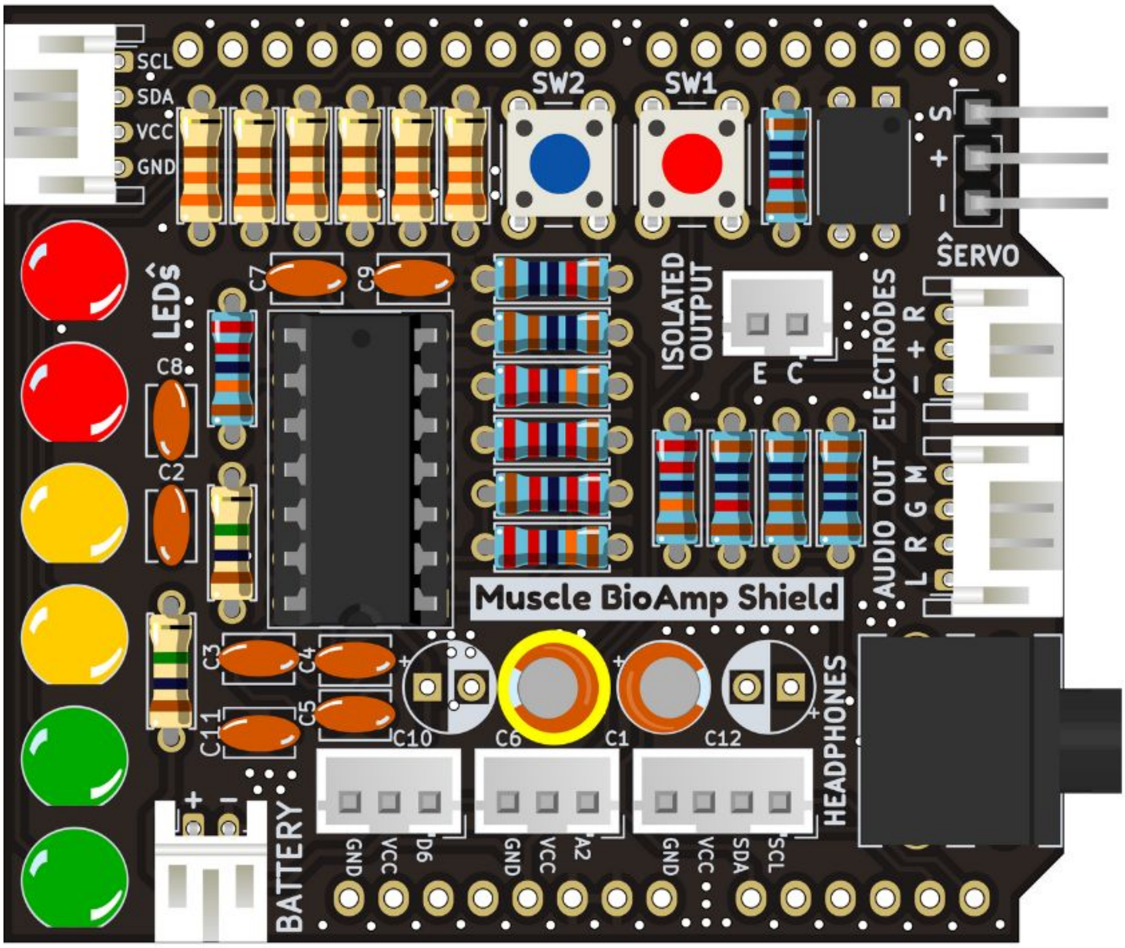


Fig. 28: **Step 21 - 1uF Capacitor**

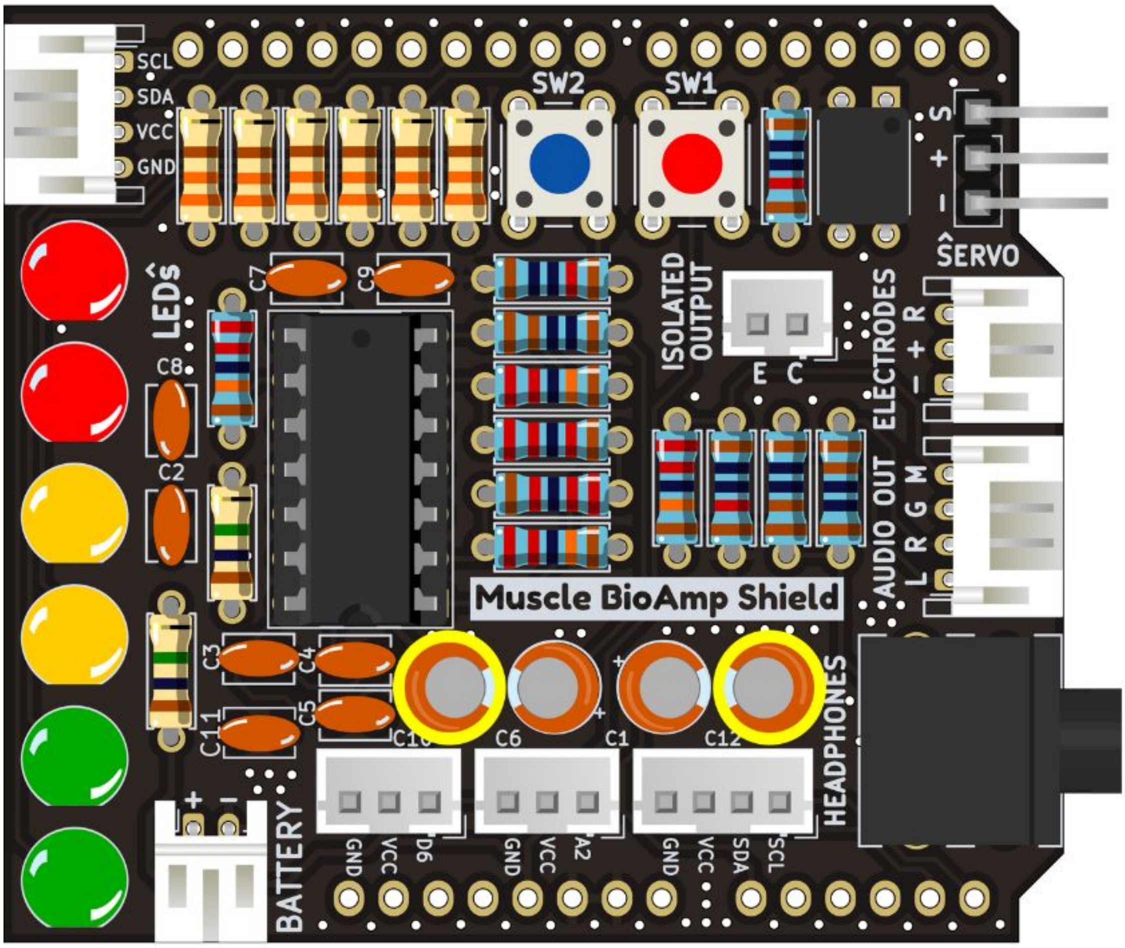


Fig. 29: **Step 22 - 470uF Capacitor**

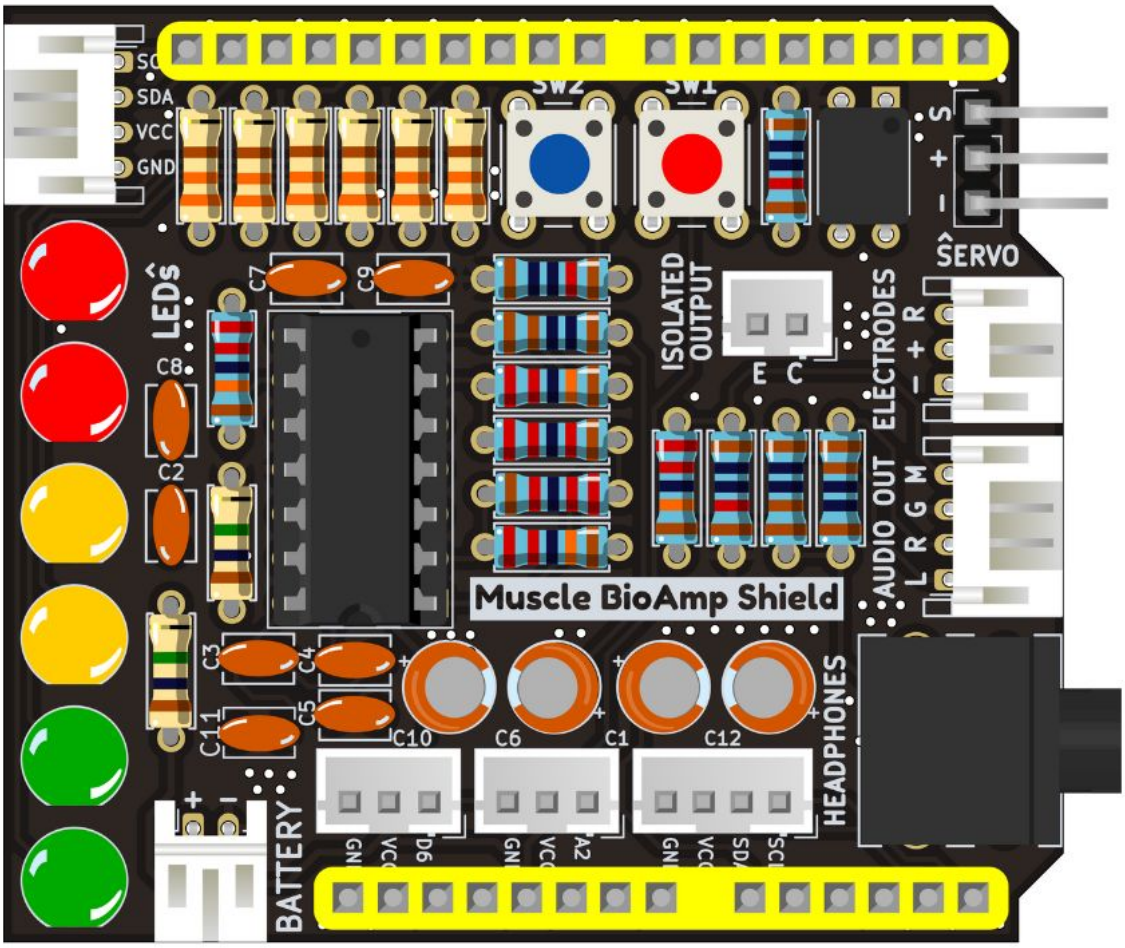


Fig. 30: **Step 23 - Header Pins**

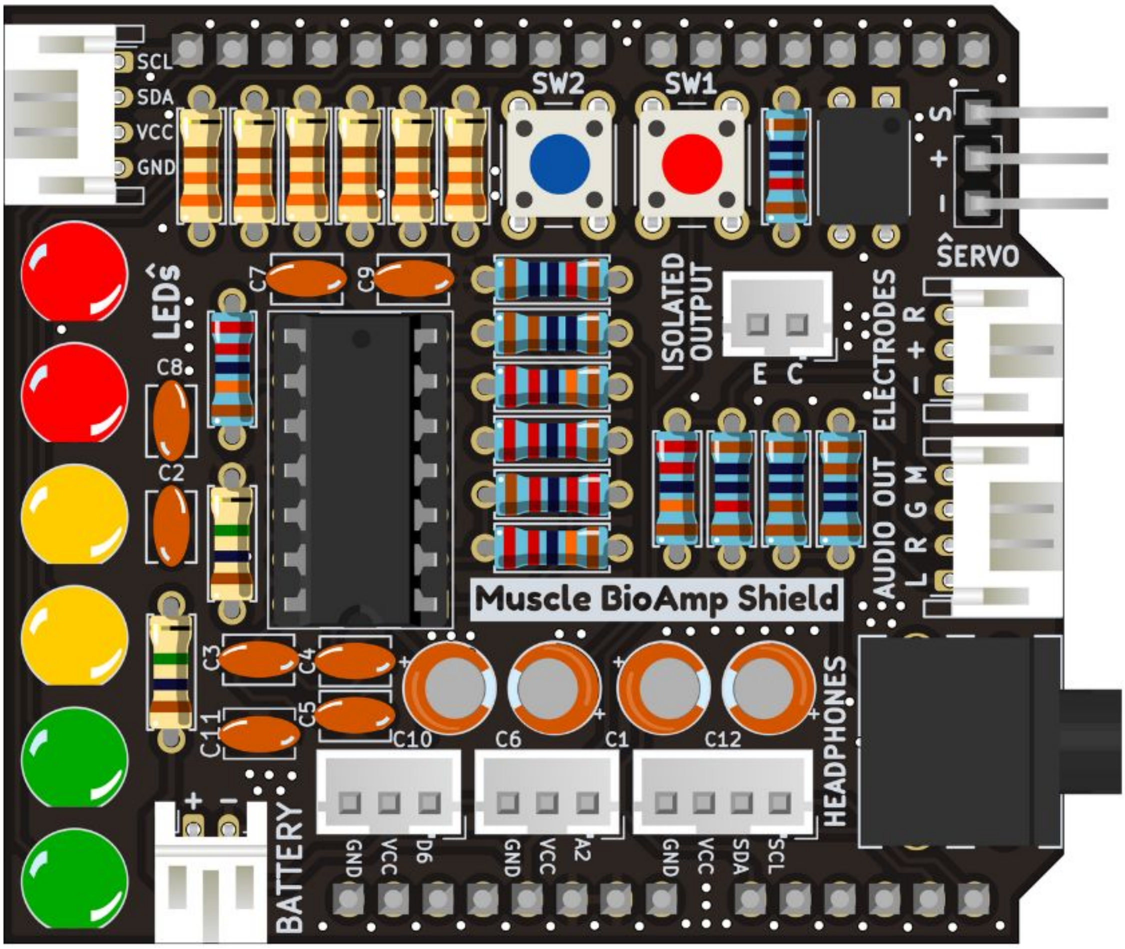
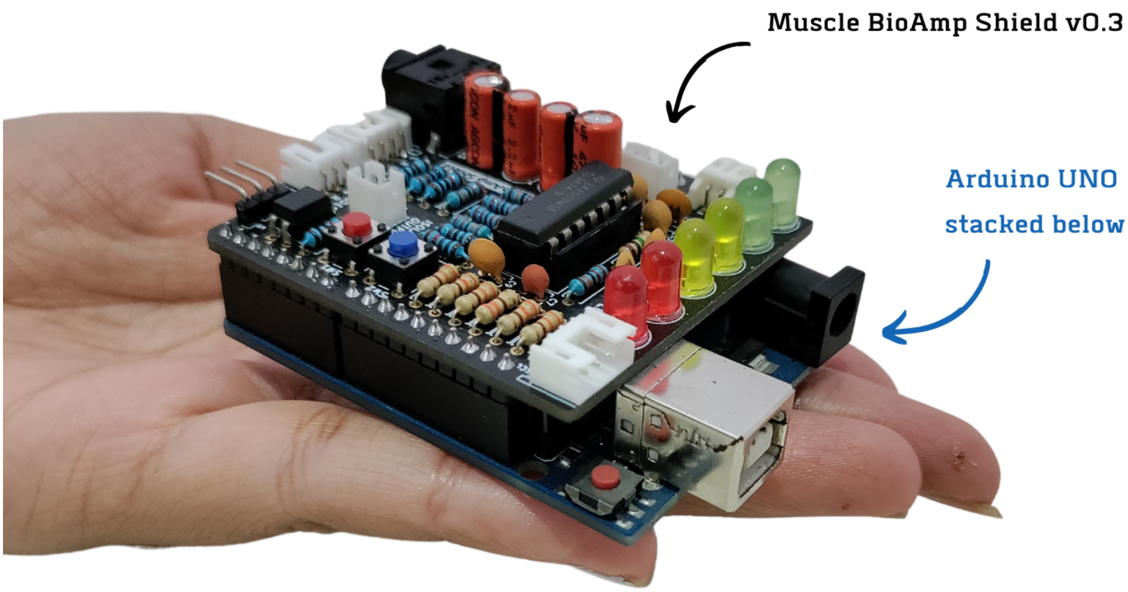


Fig. 31: **Step 24 - Assembled Shield**

3.7 Using the Sensor

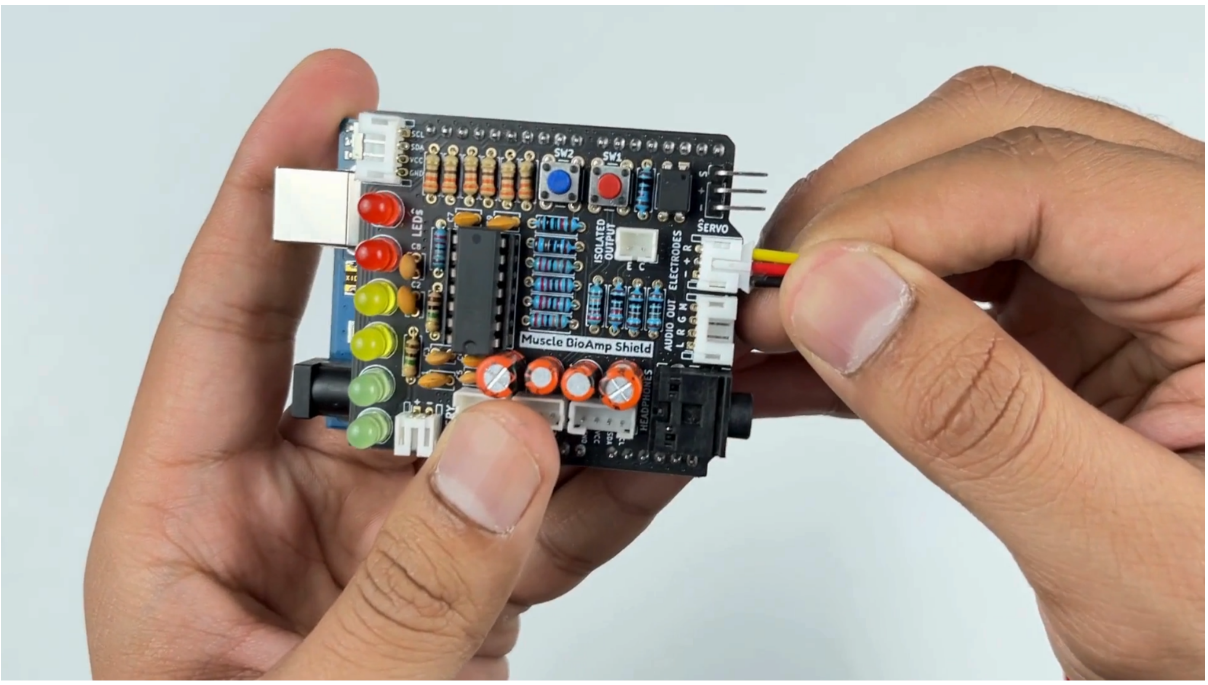
3.7.1 Step 1: Stack on Arduino Uno

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



3.7.2 Step 2: Connecting Electrode Cable

Connect the BioAmp Cable to Muscle BioAmp Shield as shown.



3.7.3 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 Guide*.

3.7.4 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.

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.

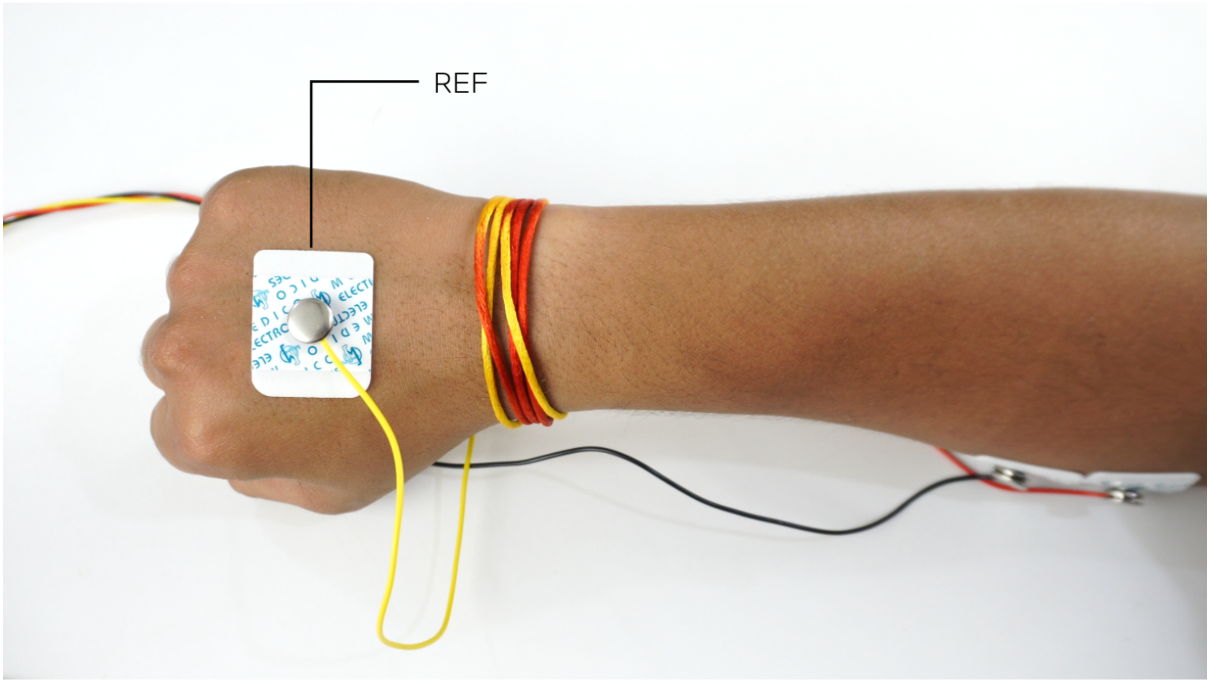


Fig. 32: *Electrode placement for REF cable*

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.

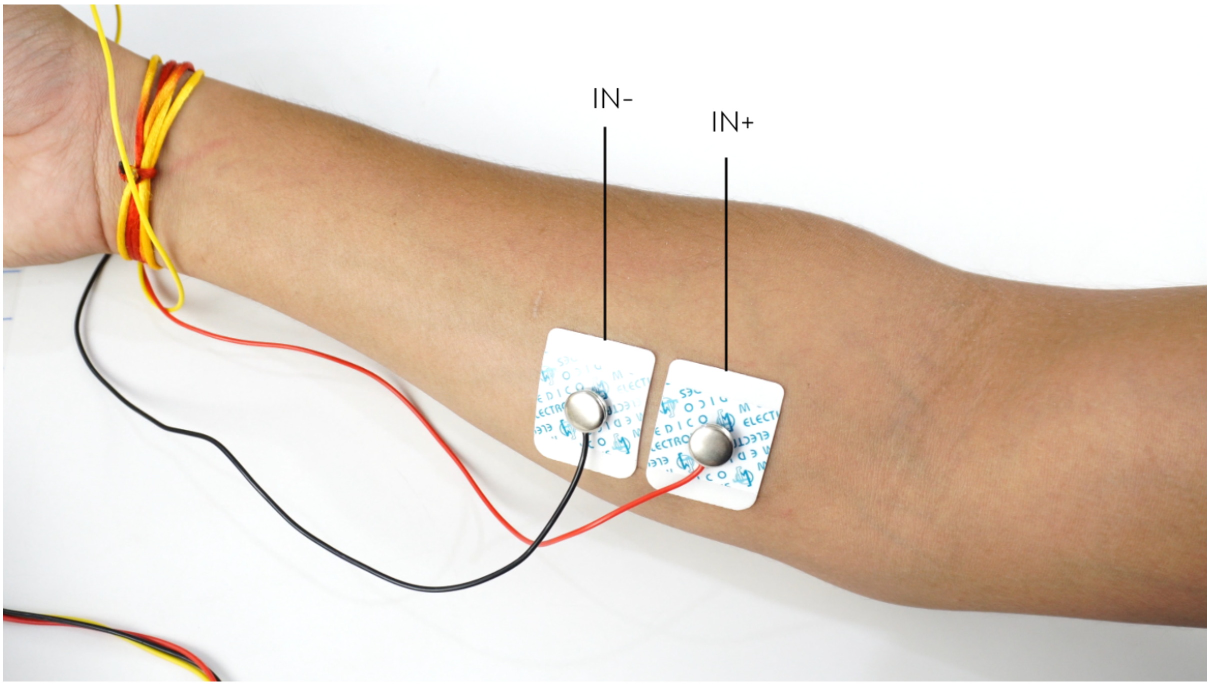


Fig. 33: *Electrode placement for IN+, IN- cables*

Tip

Visit the complete documentation on how to *assemble and use the BioAmp Bands* or follow the youtube video given below.

Tutorial on how to use the band:

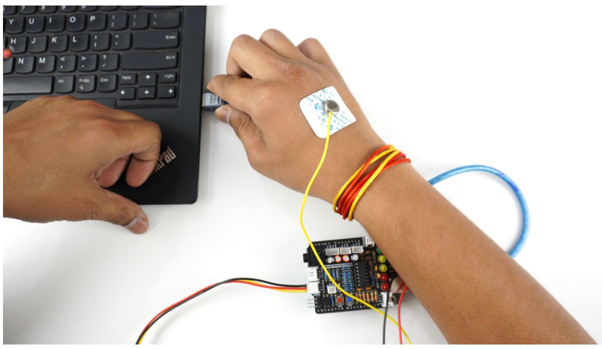
https://youtu.be/xYZdw0aesa0

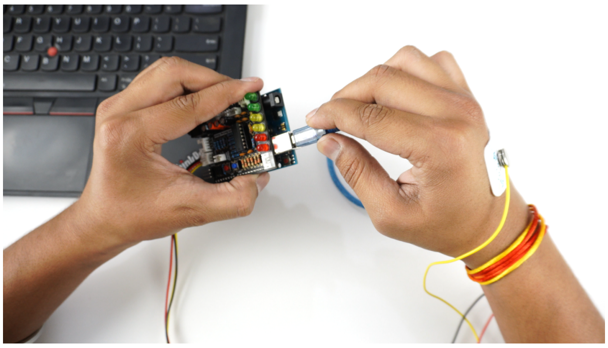
Note

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.

3.7.5 Step 5: Connect Arduino UNO to your laptop

Connect your Arduino UNO to your laptop using the USB cable.





Warning

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

3.7.6 Step 6: Uploading the code

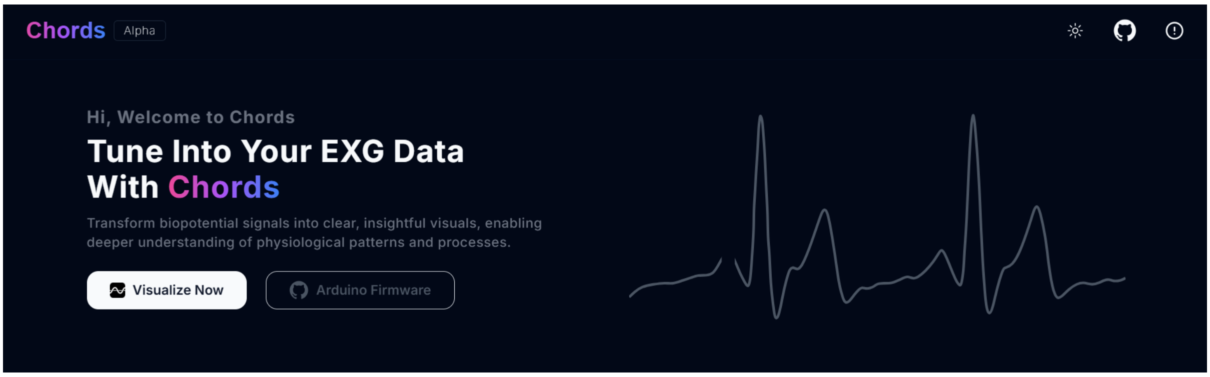
1. Go to Chords Arduino Firmware github repository, scroll down to see a list of development boards compatible with Chords Software Suite.

   Link for the Github repo: Chords Arduino Firmware

2. If you are using Arduino UNO R3, copy the arduino sketch for your board and paste it in Arduino IDE. Uncomment `#define BOARD_UNO_R3` at the start of the code.
3. If you are using Arduino Uno R4 Minima/WiFi, you just have to copy the arduino sketch for the board, paste it in Arduino IDE and upload.
4. To upload the code, go to `tools` > `board` and select you board name. If the name doesn't appear, install the required libraries. In the same menu, select the COM port on which your board 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 click on the upload button.

3.7.7 Step 7: Visualise EMG signals on Chords-Web

1. Visit chords.upsidedownlabs.tech.
2. Click on "Visualize now" button.



3. **At the bottom, you can see buttons to access various applications:**

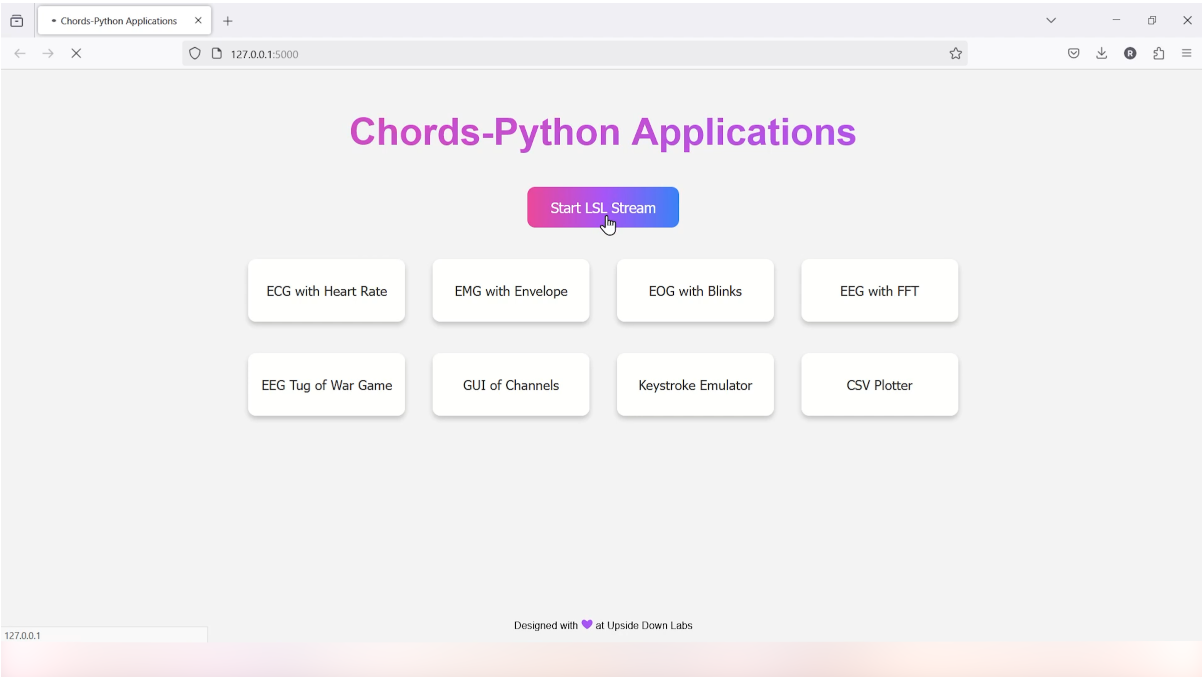
   a. Chords Visualizer: Use this application for real-time data visualization, recording and data management, filter options, and multi-channel support.

b. Serial Wizard: This interface provides real-time serial data visualization using serial plotter and monitor, optimised data rendering, baud rate selection and options to toggle between different modes.

4. Click on any of the button according to your requirement, select the COM port and click OK. You will be able to visualize your signals on the screen.

3.7.8 Step 8: Visualise EMG signals on Chords-Python

Since you have uploaded the firmware already to your board, use our python script and follow the steps given in the Chords-Python documentation for LSL streaming, CSV data logging, verbose output with detailed statistics and error reporting. Not only that, you get a complete web interface to access various applications (like ECG with heart rate, EMG with envelope, GUI of channels, CSV plotter, etc.) that you can use to further analyse your signals and create HCI/BCI projects.



3.7.9 Step 9: Visualise EMG signals on LEDs

Copy paste the Arduino Sketch given below in Arduino IDE:

LED Bar Graph

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.

3.7.10 Step 10: 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.

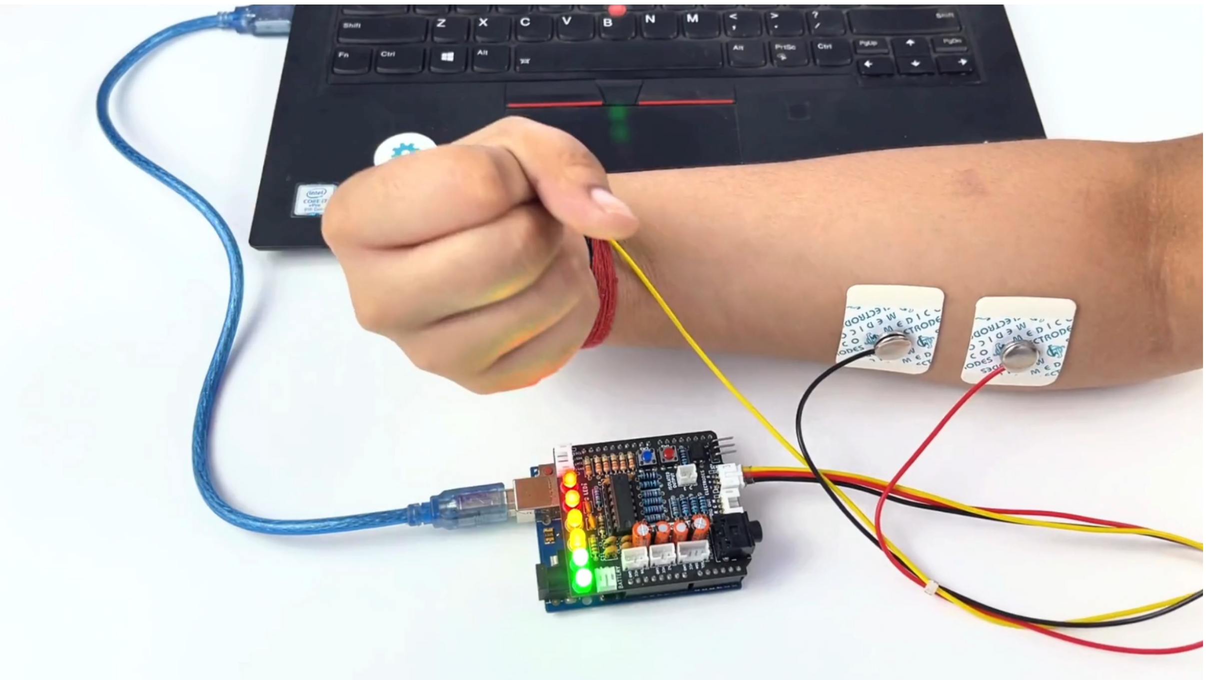


Fig. 34: *Visualise EMG signals on LEDs*

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.

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.

3.7.11 Step 11: Controlling a servo motor

Connect the servo claw to Muscle BioAmp Shield.

Copy paste the Arduino Sketch given below in Arduino IDE:

Servo Controller

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.

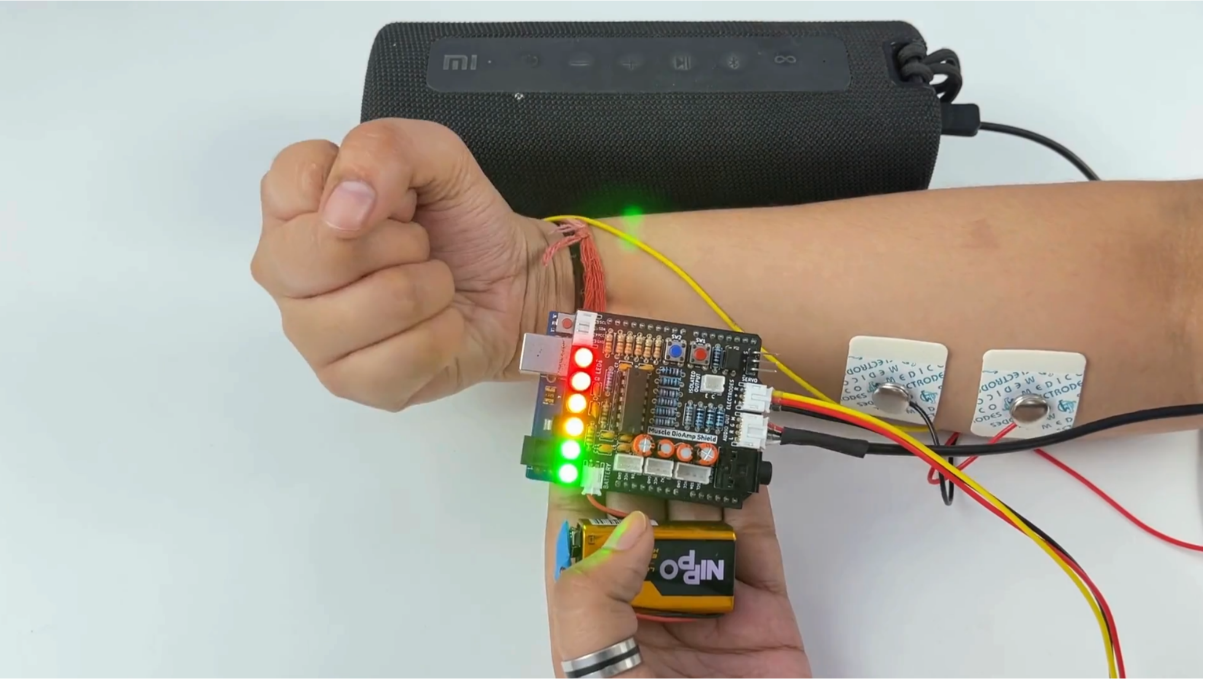


Fig. 35: Listening EMG on speakers

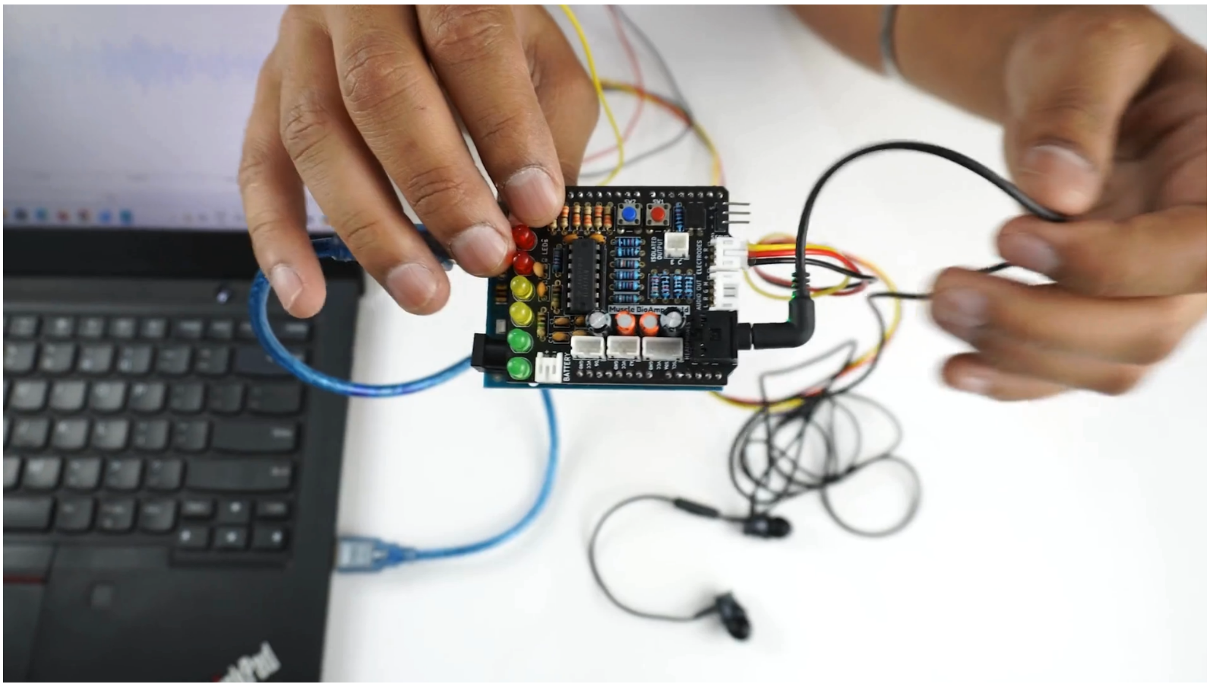


Fig. 36: *Listening EMG on a wired earphones/headphones*

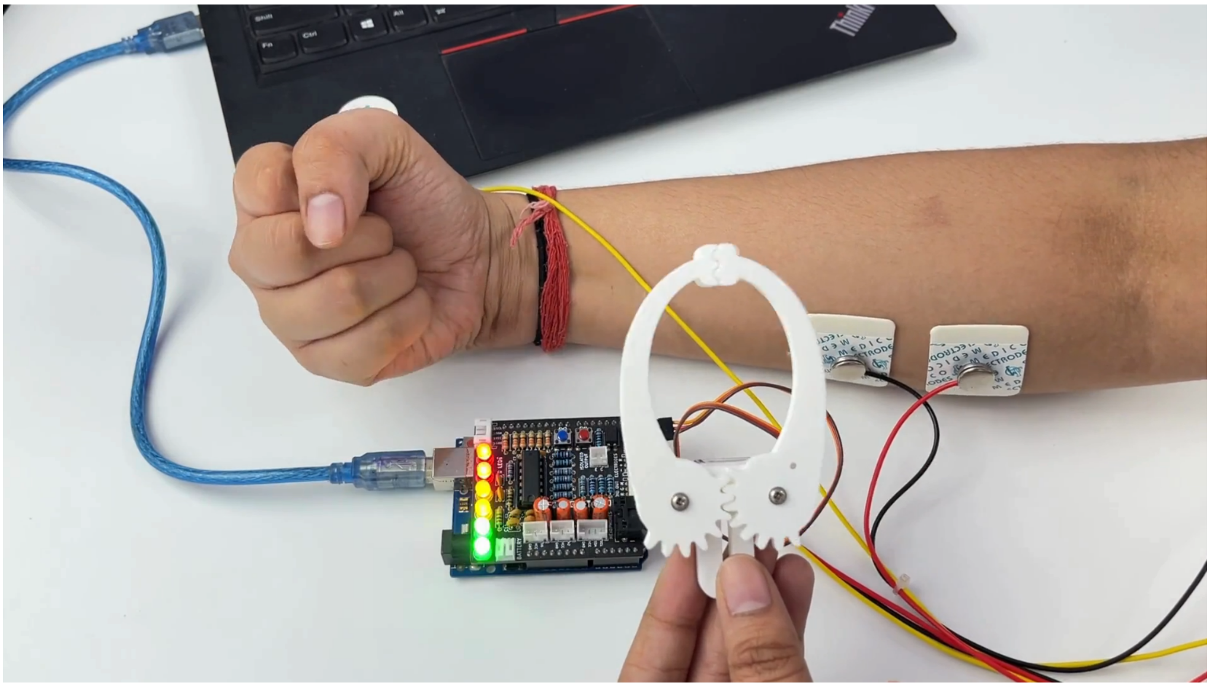
3.7.12 Step 12: Controlling a servo claw

Connect the servo claw to Muscle BioAmp Shield.

Copy paste the Arduino Sketch given below in Arduino IDE:

Claw Controller

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.



3.7.13 Step 13: 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.

> **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.

3.7.14 Step 14: Other functionalities you can explore

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.

Using STEMMA Digital port

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

Using STEMMA Analog port

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

Using user buttons

Program the 2 user buttons according to your project requirements.

CHAPTER

FOUR

SKIN PREPARATION GUIDE

4.1 Why skin preparation is important?

Proper skin preparation is crucial before recording any biopotential signal be it Electrocardiography (ECG), Electromyography (EMG), Electroencephalography (EEG), or Electrooculography (EOG).

- `Clean skin surface:` Removes dead skin cells, oils, & other substances that increases skin impedance.
- `Improve impedance:` Improves the conduction of electrical signals from the body to the recording equipment and minimizes impedance.
- `Electrode-skin contact:` Ensures optimal contact between the electrodes and the skin surface.
- `Signal quality:` Enhances the overall quality of recorded signals, providing clear & reliable data for analysis & improves the ability to capture subtle variations in biopotential signals.
- `Consistency in recordings:` Reduces variability in signal quality, making it easier to make any Human-Computer Interface (HCI), Brain-Computer Interface (BCI) project or a real-world application.
- `Long term adhesion:` Facilitates long-term adhesion & stable placement of electrodes to the skin during extended signal monitoring.

4.2 Kit Contents

Nuprep gel	Mildly abrasive, highly conductive gel that should be applied before placing the electrodes on the skin to improve signal quality & enhances the performance of monitoring electrodes.
Electrode Gel	Highly conductive gel that acts as a coupling agent between dry electrodes and the skin to aid the transmission of biopotential signals like ECG, EMG, EOG, or EEG.
Ten20 paste	Contains the right balance of adhesiveness and conductivity, enabling the dry electrodes to remain in place while allowing the transmittance of biopotential signals.
Alcohol Swabs/Wet wipes	Soft & non-woven pads that helps in cleaning the skin surface and does not leave any residue.
Cotton Swabs	Useful while applying nuprep gel or ten20 paste.

4.3 Steps to follow

You can follow the steps given below to do the skin preparation properly:

4.3.1 Step 1: Identify the targeted area

Identify the target area where the gel electrodes or BioAmp Bands will be placed for recording the biopotential signals.

4.3.2 Step 2: Apply NuPrep gel

Take a small amount of NuPrep gel using a cotton swab and apply it on your targeted area.

4.3.3 Step 3: Clean the skin surface

Use gentle, circular motions to rub the gel on the skin surface. This removes all the dead skin cells & improves conductivity.

Warning

Do not rub the gel for too long as it has abrasive properties and may cause skin redness and irritation.

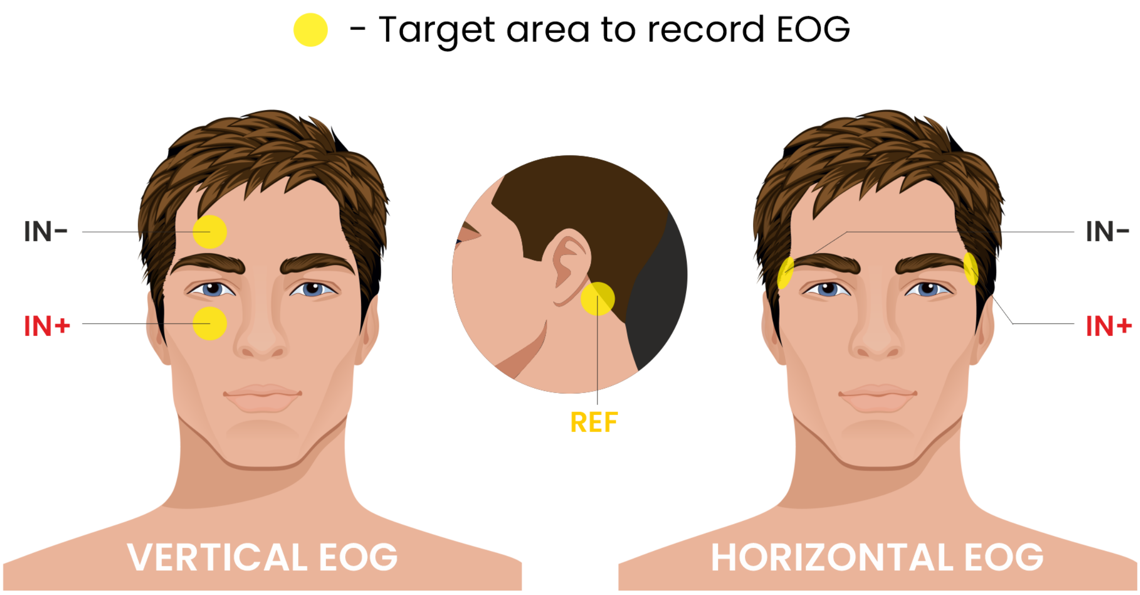


Fig. 1: Target area to record EOG

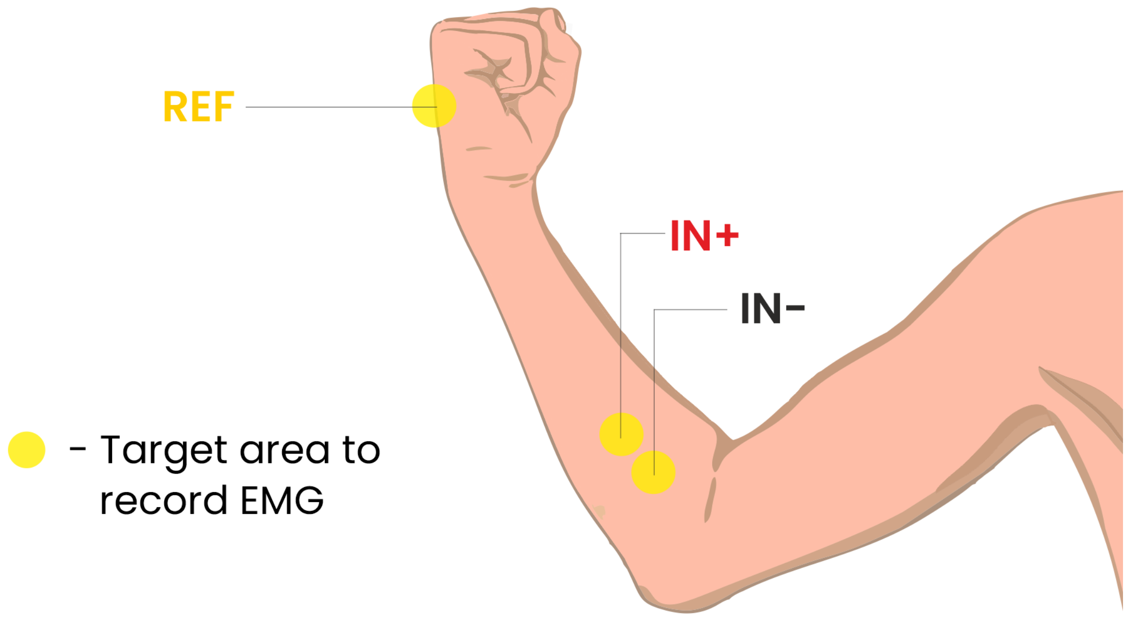


Fig. 2: Target area to record EMG

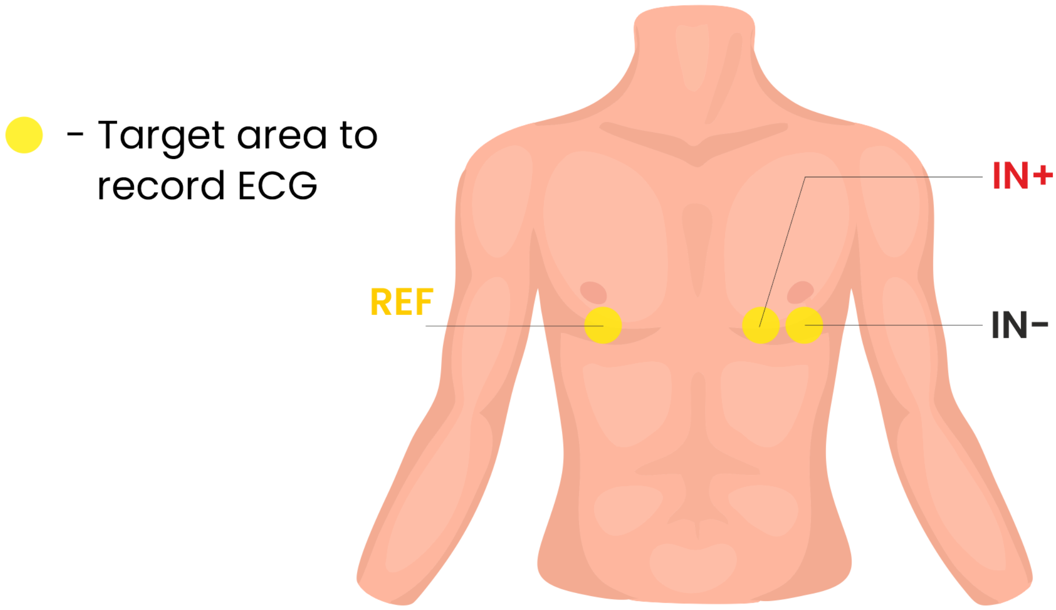


Fig. 3: Target area to record ECG

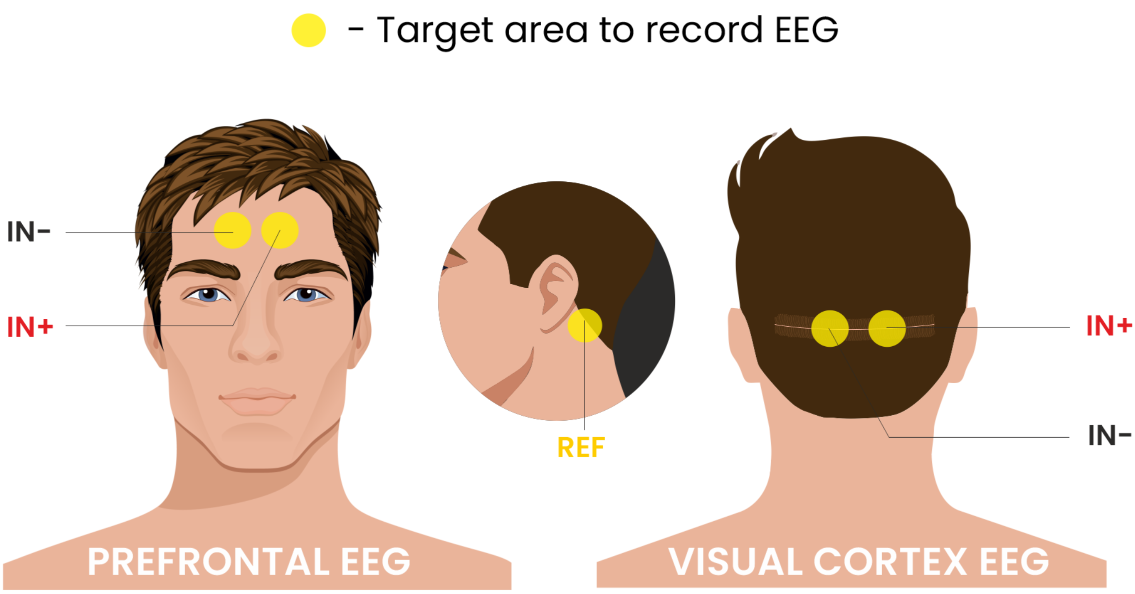


Fig. 4: Target area to record EEG

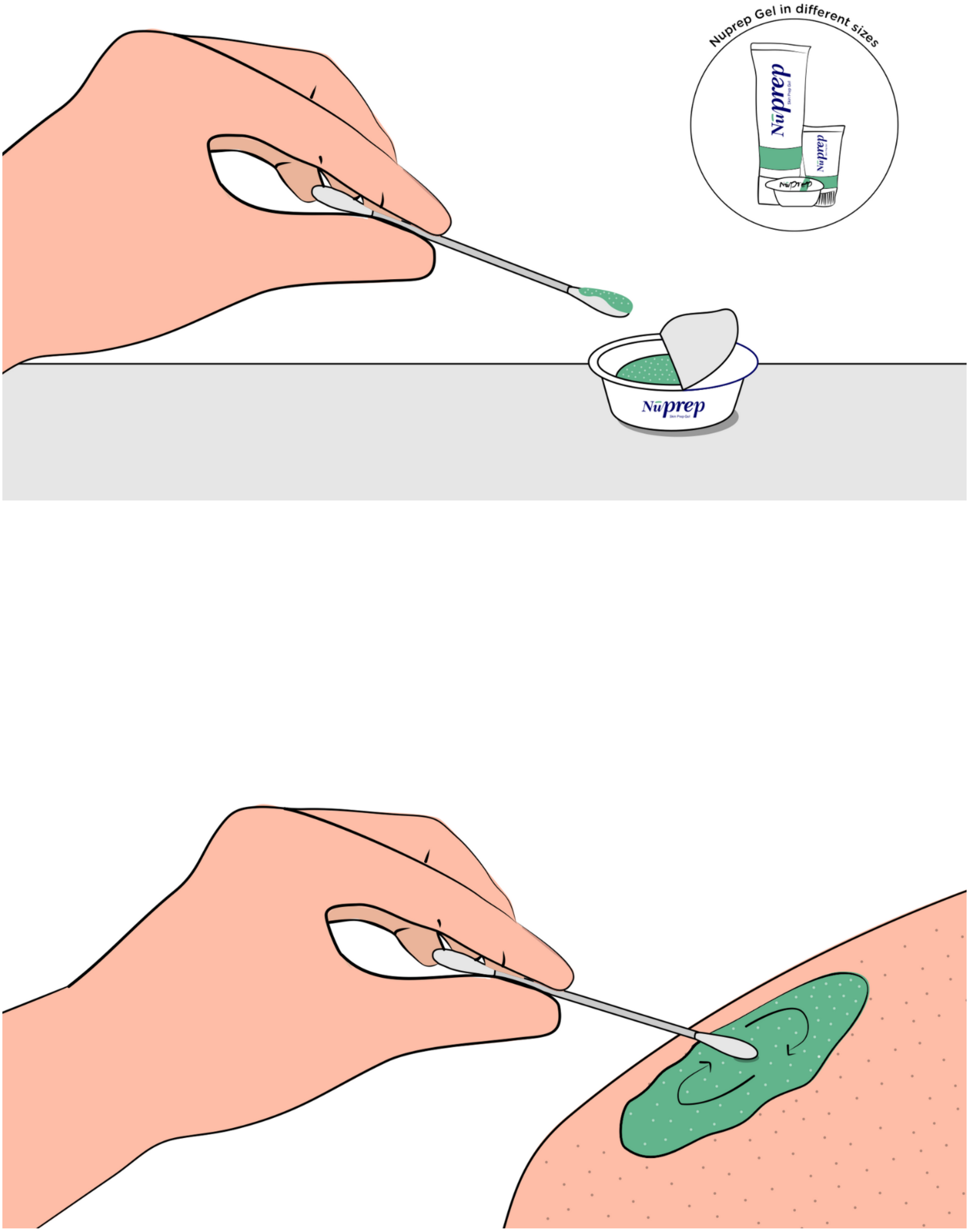


Fig. 5: Rub the gel gently using the cotton swab

4.3.4 Step 4: Wipe off the gel

Wipe away excess gel with alcohol swabs or wet wipes.

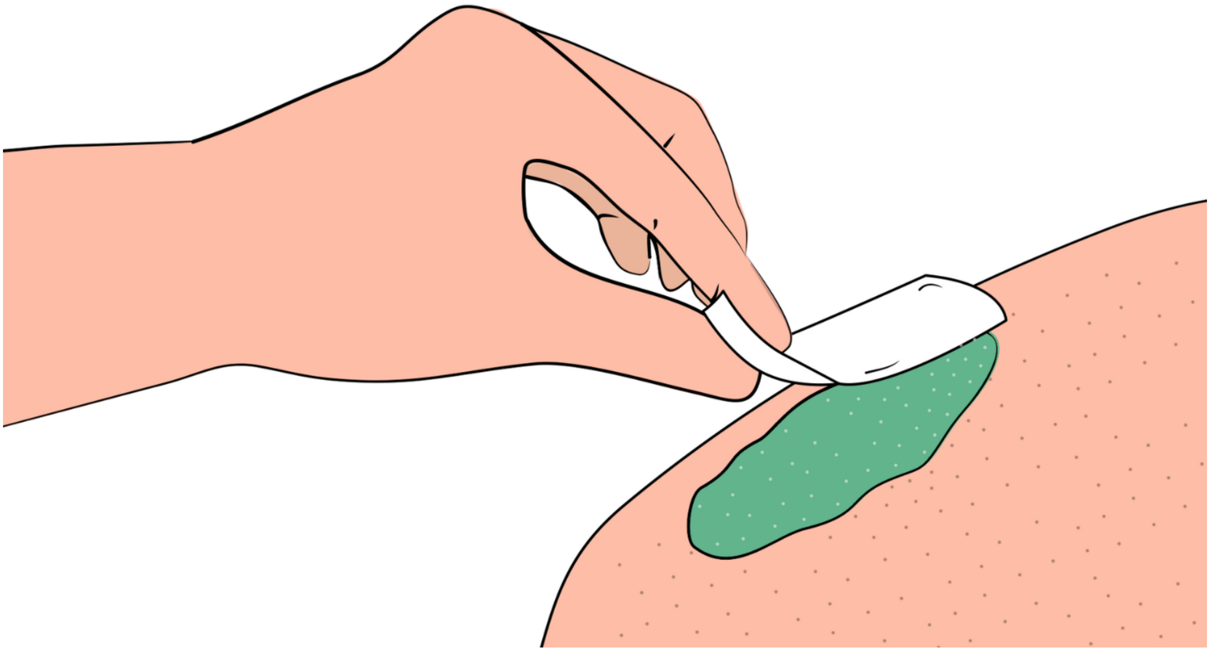


Fig. 6: Wipe away access gel

Warning

- Using alcohol swabs can dry out the skin, so don't use them if your skin is already dry.
- Close your eyes while using the alcohol swabs for EOG recording else it may cause eye redness & irritation.

4.3.5 Step 5: Measuring the signals

Now you can either use gel electrodes or BioAmp bands for the signal recording.

Using gel electrodes

Connect the BioAmp cable to gel electrodes, peel the plastic backing from electrodes and place the IN+, IN-, REF cables according to your specific biopotential recording.

Note

While placing the gel electrodes on the skin, make sure to place the non-sticky tab of the electrode in the direction opposite to your hair growth. This allows you to remove the electrodes easily without pulling off much body hair.

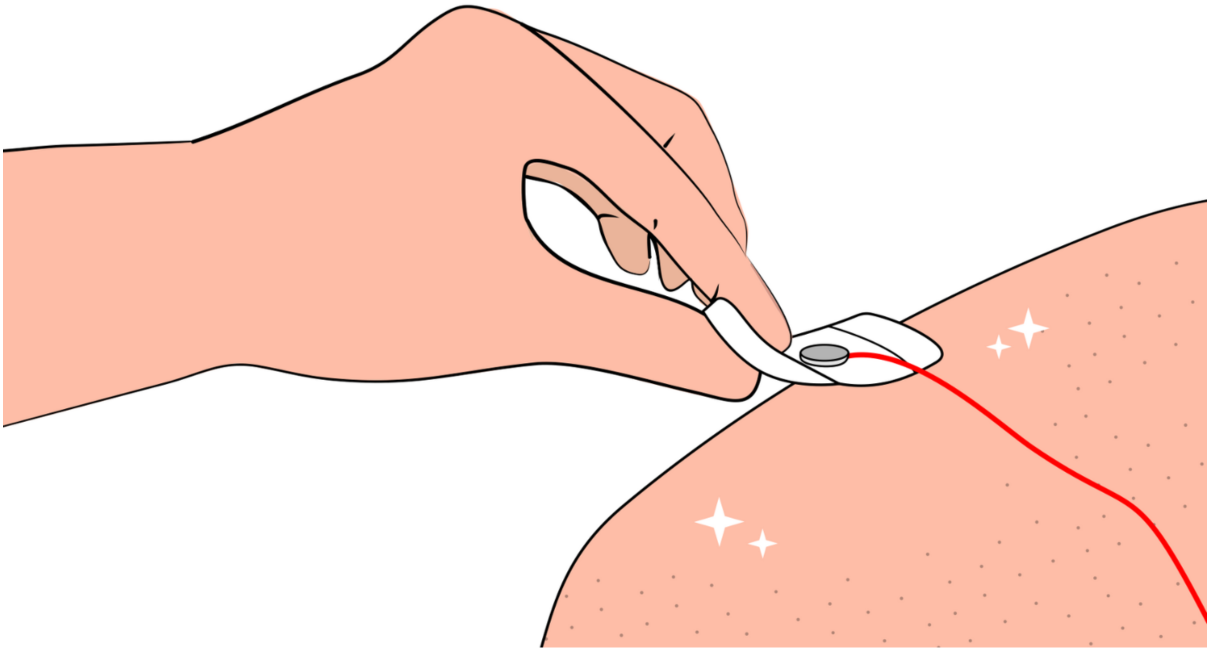


Fig. 7: Placing gel electrodes on skin surface

Using BioAmp bands

Connect the BioAmp cable to your BioAmp band. Now apply a small amount of `electrode gel` or `Ten20 conductive paste` on the dry electrodes between the skin and metallic part of BioAmp cable. This improves the signal conductivity, enhancing overall signal quality.

> **Note**
>
> The above graphics demonstrates the use of electrode gel/Ten20 paste with Muscle BioAmp Band. Similarly you can use Brain BioAmp Band and Heart BioAmp Band. Refer to *Using BioAmp Bands* guide to assemble and use all the BioAmp Bands correctly.

Now you are all set! Make all the connections correctly and start recording your biopotential signals.

> **Warning**
>
> NuPrep gel, Ten20 paste and the alcohol swabs shouldn't be used if you have a history of skin allergies to lotions and cosmetics.

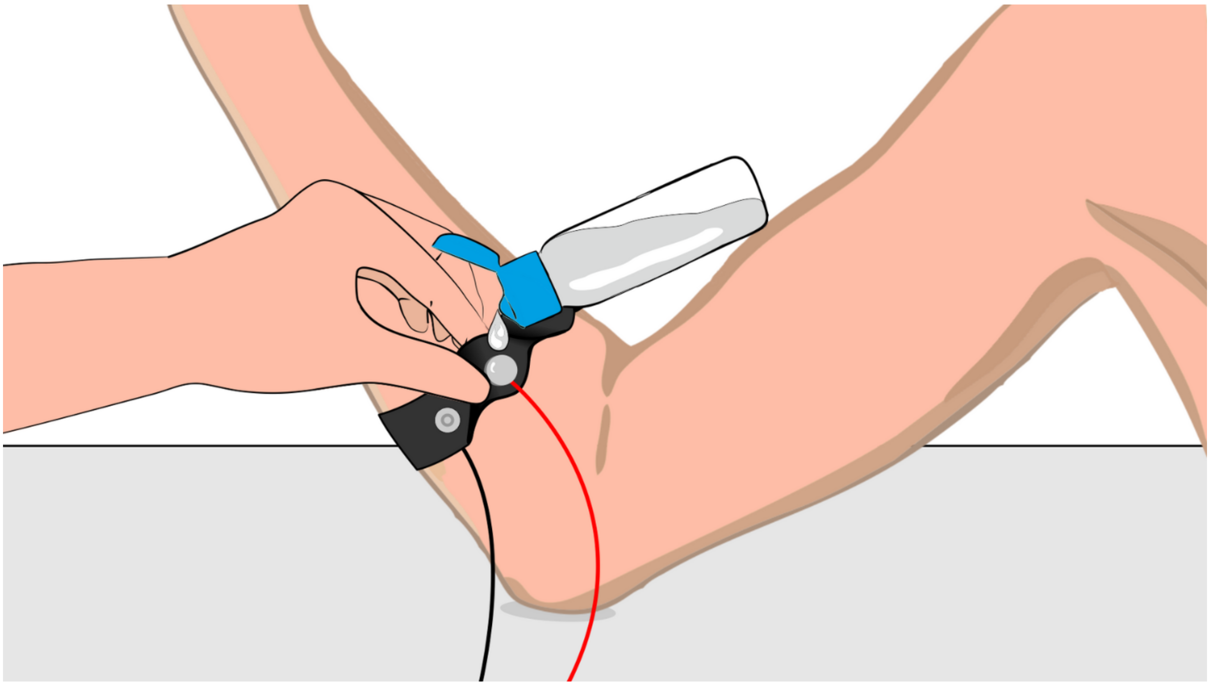


Fig. 8: Method 1: Using Electrode gel

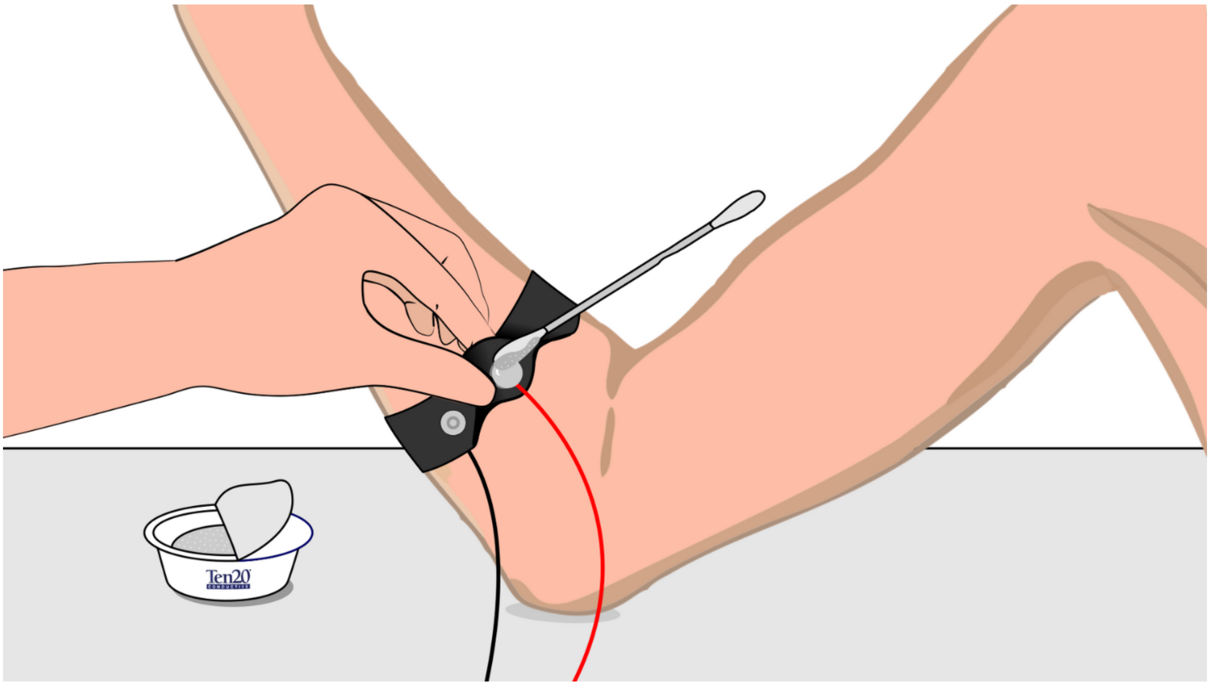


Fig. 9: Method 2: Using Ten20 paste

CHAPTER

FIVE

USING BIOAMP BANDS

5.1 Overview

BioAmp Bands are dry electrode-based stretchable bands that allows you to record biopotential signals from your body be it from brain (EEG), muscles (EMG) or heart (ECG). These bands can only be used with our BioAmp Hardware by making the connections using BioAmp Cable.

5.2 Why use BioAmp Bands?

Usually, people use gel electrodes to record biopotential signals from the skin surface. But, it has its own disadvantages. So we came up with these BioAmp Bands using which users can enjoy a more comfortable, cost-effective, and hassle-free experience while recording biopotential signals.

- Comfort: BioAmp Bands are generally more comfortable to wear than gel electrodes, especially for long-term recordings. They conform to the body's shape and avoid the sticky, sometimes irritating sensation of gel electrodes.
- Reusability: Unlike gel electrodes, which are often single-use and need to be replaced frequently, BioAmp Bands can be reused multiple times. This makes them more cost-effective and environmentally friendly.
- Ease of Use: These bands are easy to wear and adjust, reducing the hassle of setup and ensuring consistent placement.
- Hygiene: They can be easily cleaned and sanitized between uses, reducing the risk of skin irritation and infections. Gel electrodes, on the other hand, can leave residue on the skin surface.
- Performance: The bands can provide stable and reliable signal recordings depending on your environment conditions. For hot/humid conditions, the bands usually perform better while recording the signals. But if the weather is cold causing dry skin, then it is recommended to prepare the skin properly and apply electrode gel between the metallic part of cable and skin surface. If you feel that the skin impedence is increasing, then reapply electrode gel frequently. The other option is to use gel electrodes after preparing the skin properly.

5.3 Types of BioAmp Bands

There are 3 types of BioAmp Bands and all these bands offer targeted and efficient solutions for recording biopotential signals from the muscles, heart, and brain, making them versatile tools for a wide range of HCI/BCI applications.

5.3.1 1. Muscle BioAmp Band

Muscle BioAmp Band (EMG Band) is a stretchable band that can be connected to any of our Muscle BioAmp Hardware or any EXG sensor using a BioAmp Cable. It allows you to record your muscle signals hassle-free.

Length	13 inches
Stretchability	2X (Upto 26 inches)
Usability	Reusable as it comes with washable fabric
Interface	Snap electrodes
Compatible Hardware	Muscle BioAmp Hardware or any EXG sensor
BioPotentials	EMG
No. of channels	1
Wearable	Yes

5.3.2 2. Heart BioAmp Band

Heart BioAmp Band (ECG Band) is a stretchable band that can be connected to any of our Heart BioAmp Hardware or any EXG sensor using BioAmp Cable. It allows you to record your ECG signals hassle-free.

Length	37 inches
Stretchability	2X (Upto 74 inches)
Usability	Reusable as it comes with washable fabric
Interface	Snap electrodes
Compatible Hardware	Heart BioAmp Hardware or any EXG sensor
BioPotentials	ECG
No. of channels	1
Wearable	Yes

5.3.3 3. Brain BioAmp Band

Brain BioAmp Band (EEG Band) is a stretchable band that can be connected to any of our Brain BioAmp Hardware or any EXG sensor using BioAmp Cable to record signals from the brain hassle-free.

Length	15.5 inches
Stretchability	2X (Upto 31 inches)
Usability	Reusable as it comes with washable fabric
Interface	Snap electrodes
Compatible Hardware	Brain BioAmp Hardware or any EXG sensor
BioPotentials	EEG
No. of channels	2 or 6
Wearable	Yes

You can get either a 2-channel or a 6-channel Brain BioAmp Band according to your project or research requirements:

2-Channel Brain BioAmp Band

It can be used to record EEG signals up to 2 channels either from the visual cortex (back of your head) or the prefrontal cortex part of brain.

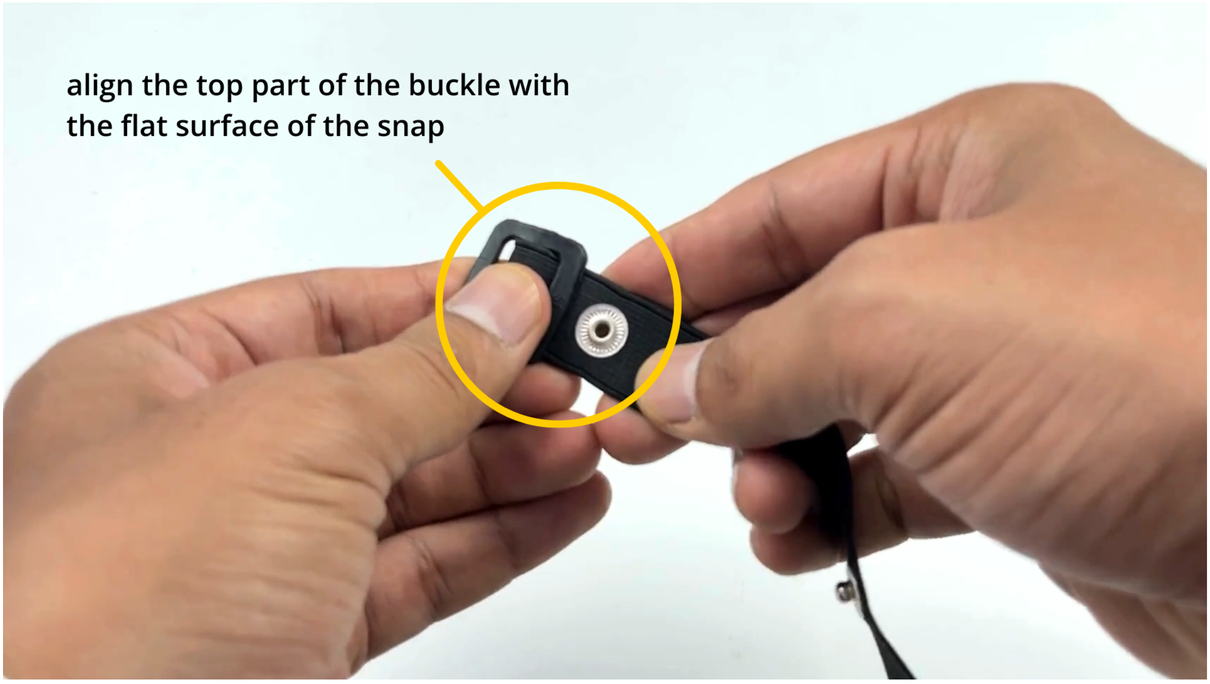
6-Channel Brain BioAmp Band

It can be used to record EEG signals up to 2 channels either from the visual cortex (back of your head) or the prefrontal cortex part of brain.

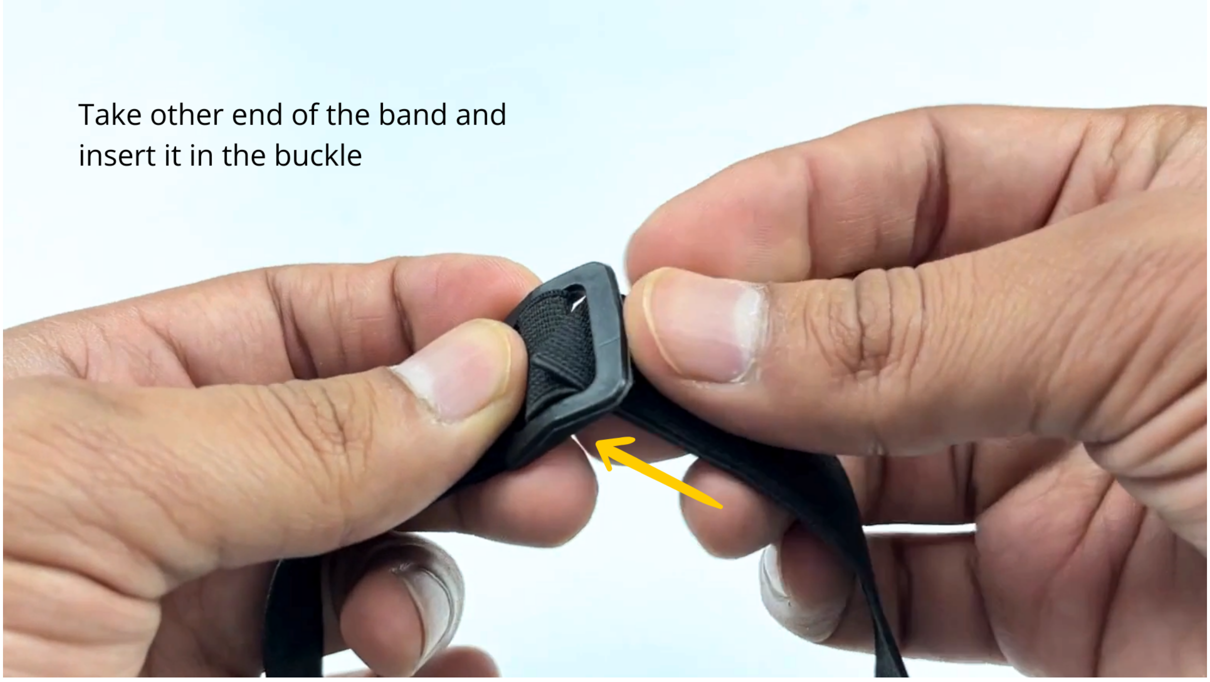
5.4 Using Muscle BioAmp Band

5.4.1 Assembly

1. Take your Muscle BioAmp Band, hold the side of the band that has buckle on it and align the top part of the buckle with the flat surface of the snap.



1. Take the other end of the band and insert it in the buckle.
3. Your band is now ready to use. You can also adjust the size of the band according to your targeted muscle.


Take other end of the band and
insert it in the buckle


Insert this end of the band into the buckle
as shown and pull it to finish the assembly

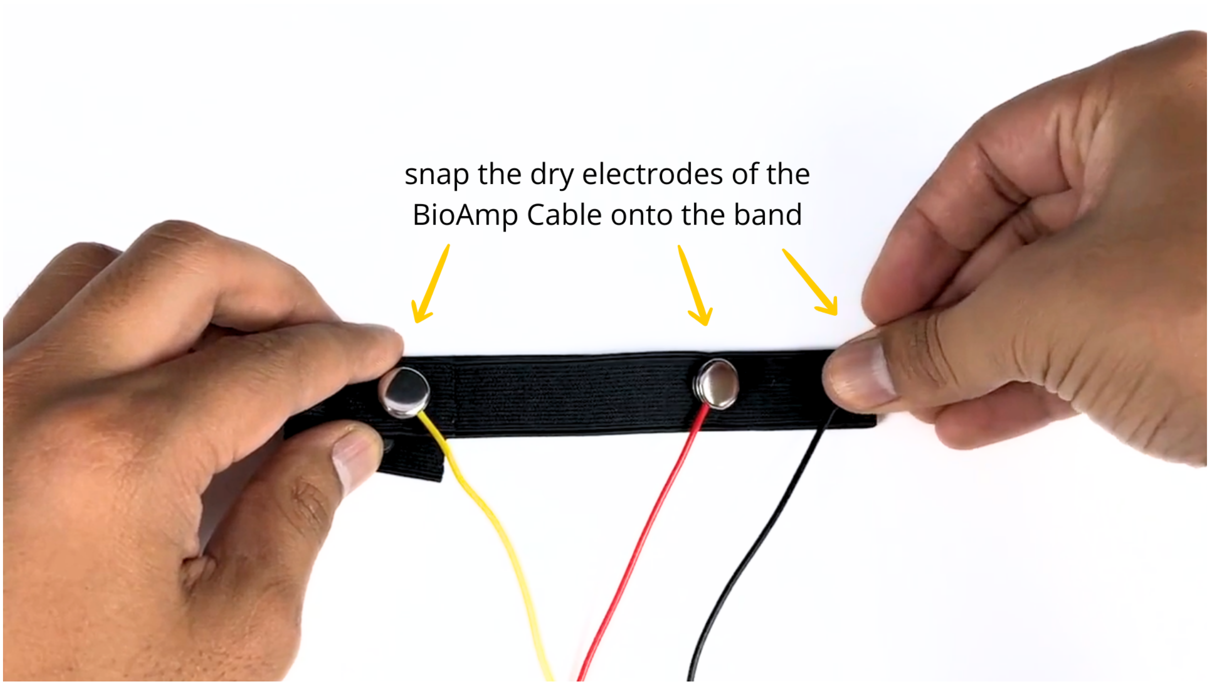
5.4.2 Skin Preparation

Apply Nuprep Skin Preparation Gel on the skin surface where dry 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.

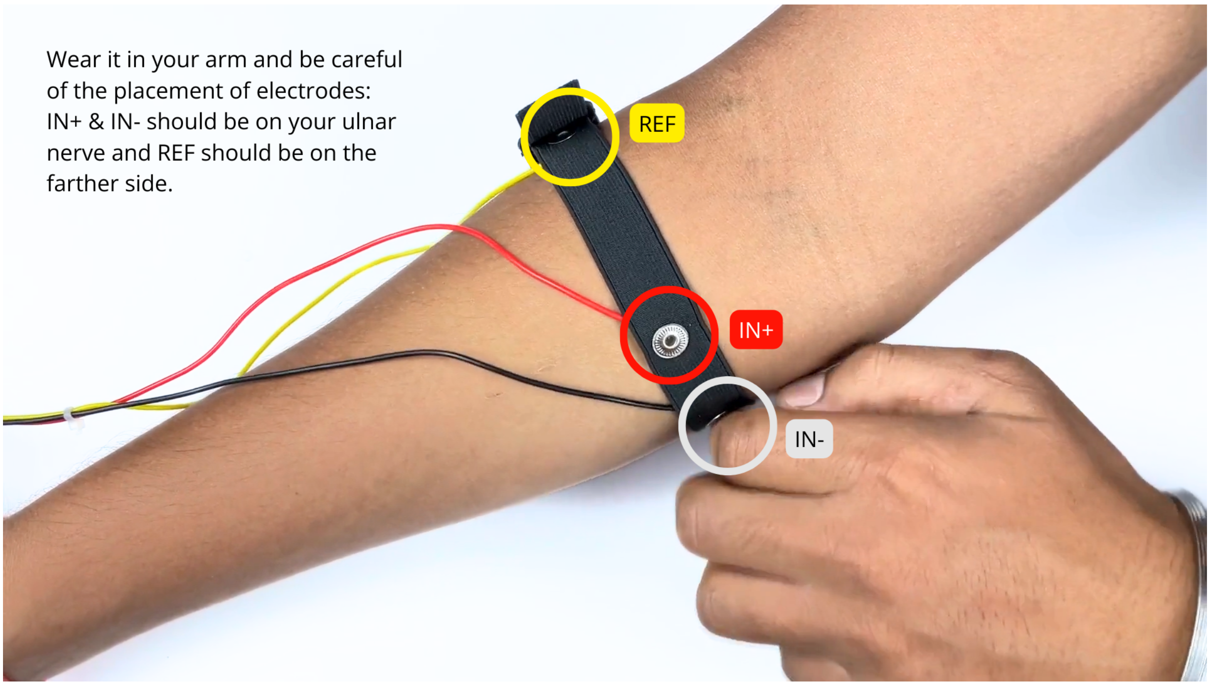
For more information, please check out detailed step by step *Skin Preparation Guide*.

5.4.3 Measure EMG

1. Flip the band and snap the dry electrodes of the BioAmp Cable on it as shown below.



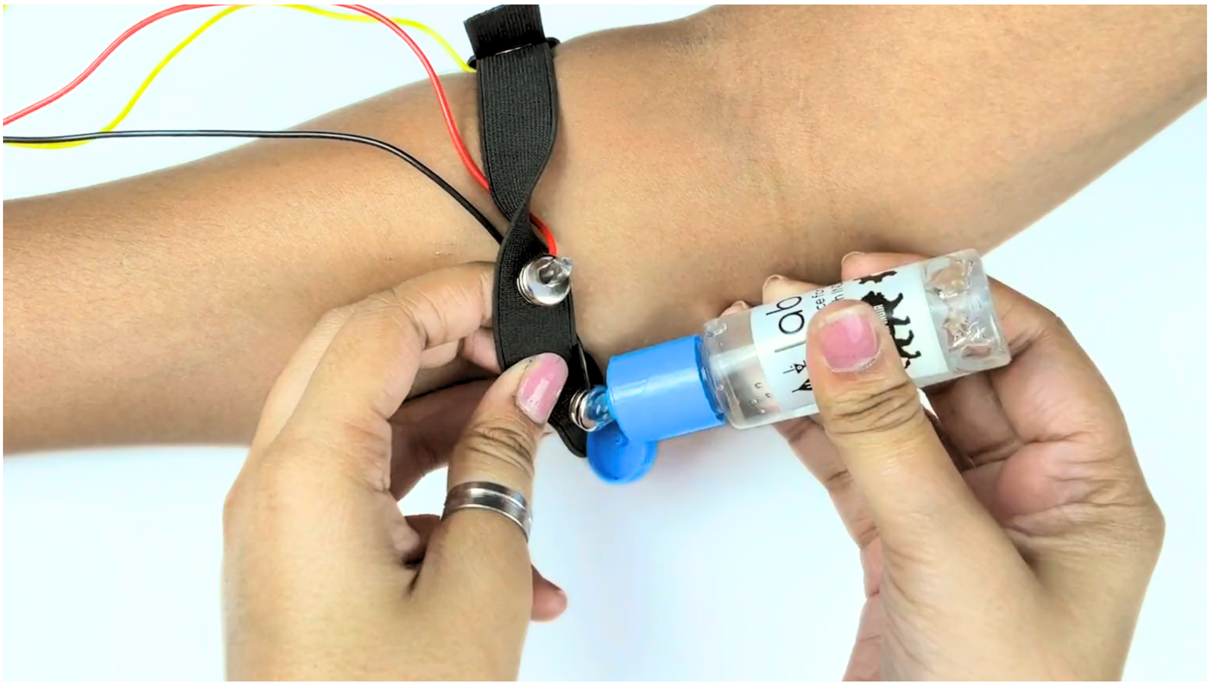
1. Flip the band again and wear it on your arm in such a way that IN+ and IN- are placed on the arm near the ulnar nerve and REF (reference) on the far side of the band.



Note

Make sure the dry electrodes (shiny parts of the BioAmp Cable) are in direct contact with the skin.

3. Now put a small amount of electrode gel or Ten20 paste between the skin and dry electrodes to get the best signal acquisition.



Note

- After using the band, don't leave the gel residue on the dry electrodes longer than an hour as it may corrode them over a period of time.
- Wash the band with liquid soap and rinse it properly after every use. Use it again only when it is completely dry.

5.5 Using Heart BioAmp Band

5.5.1 Skin Preparation

Apply Nuprep Skin Preparation Gel on your chest where dry 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 Guide*.

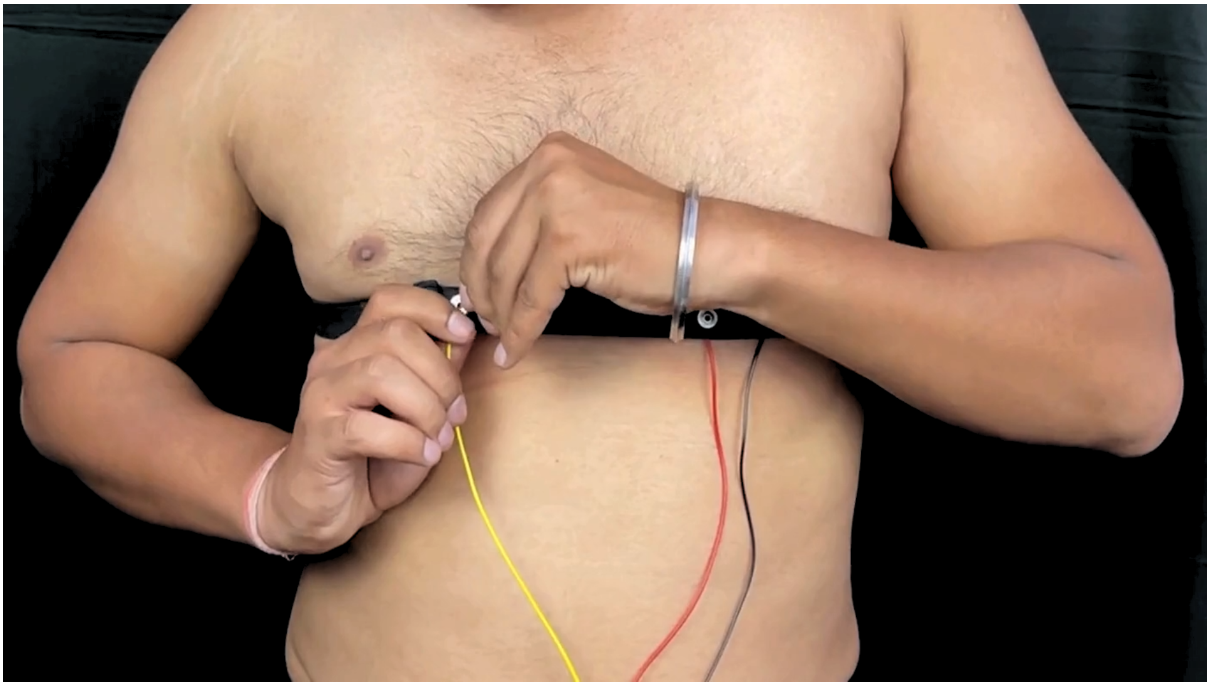
5.5.2 Assembly

1. Take your Heart BioAmp Band and wrap the band around your chest in such a way that the pointy part of the snap touches your chest and the flat part is on the outer side.

2. Now insert the loose end of the band into the buckle and tighten it by pulling the strap.
3. Your band is now ready to use. You can also adjust the size of the band according to your chest size.

5.5.3 Measure ECG

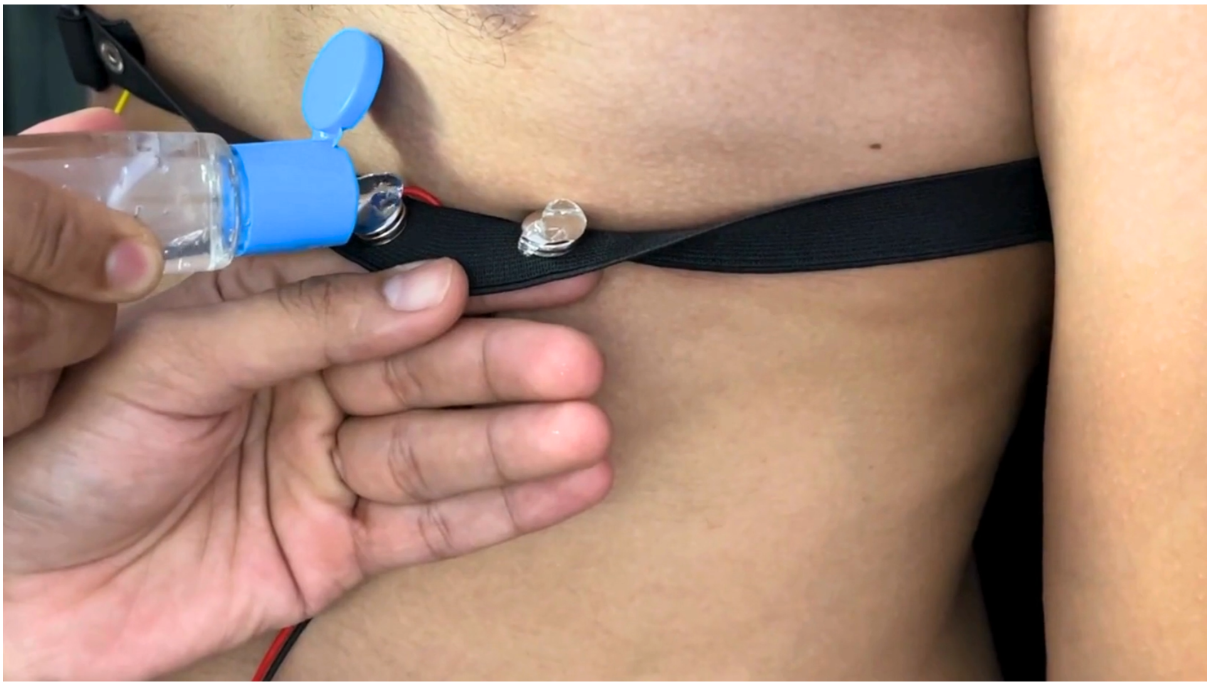
1. Snap the IN- cable on the left most side of the band, IN+ cable in the middle, and REF cable on the right side as shown below.



Note

Make sure the dry electrodes (shiny parts of the BioAmp Cable) are in direct contact with the skin.

2. Now put a small amount of electrode gel or Ten20 paste between the skin and dry electrodes to get the best signal acquisition.



Note

- After using the band, don't leave the gel residue on the dry electrodes longer than an hour as it may corrode them over a period of time.
- Wash the band with liquid soap and rinse it properly after every use. Use it again only when it is completely dry.

5.6 Using Brain BioAmp Band

5.6.1 Assembly

You get the band in two parts - the longer part consists of buckles at both ends and the shorter one has loose ends on both sides.

1. Hold one end of the longer band and align the top part of the buckle with the flat surface of the snap.
2. Now take the shorter band and insert it into the buckle of longer band.
3. Repeat step 1 and 2 for the other buckle on the longer band.
4. Your band is now ready to use. You can also adjust the size of the band according to your head size.

5.6.2 Skin Preparation

Apply Nuprep Skin Preparation Gel on your targeted area (visual cortex or prefrontal cortex) where dry 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 Guide*.

5.6.3 Measure 1-channel EEG

1. Flip the band, take your BioAmp Cable, and snap the REF cable on a gel electrode. Now snap the IN- and IN+ cable on:

- Fp1 and Fp2 positions for recording EEG from prefrontal cortex
- O1 and O2 positions for recording EEG from visual cortex

Note

The electrode positions mentioned above are according to International 10-20 sytem for recording EEG.

2. Flip the band again and wear it in a way so that the dry electrodes (shiny parts of the cable) are in contact with:

- skin surface on the forehead (if recording from prefrontal cortex)
- scalp surface on the back side of your head (if recording from visual cortex)

3. Peel of the plastic backing of the gel electrode and place it on the bony part behind your earlobe.

Note

While placing the gel electrodes on the skin, make sure to place the non-sticky tab of the electrode in the direction opposite to your hair growth. This allows you to remove the electrodes easily without pulling off much body hair.

4. Now put a small amount of electrode gel or Ten20 paste between the skin/scalp and dry electrodes to get the best signal acquisition.