BioAmp EXG Pill

Upside Down Labs

Jul 18, 2024

CONTENTS

CHAPTER

ONE

BIOAMP EXG PILL

v1.0

1.1 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 much accurately.

1.2 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. Pair it with any MCU with an ADC. It is by default compatible with 5V but you can make it compatible with 3.3V as well using a voltage divider.
6. Configure the gain, band pass filter and electrode count according to your requirements.

1.3 Features & Specifications

Operating Voltage	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

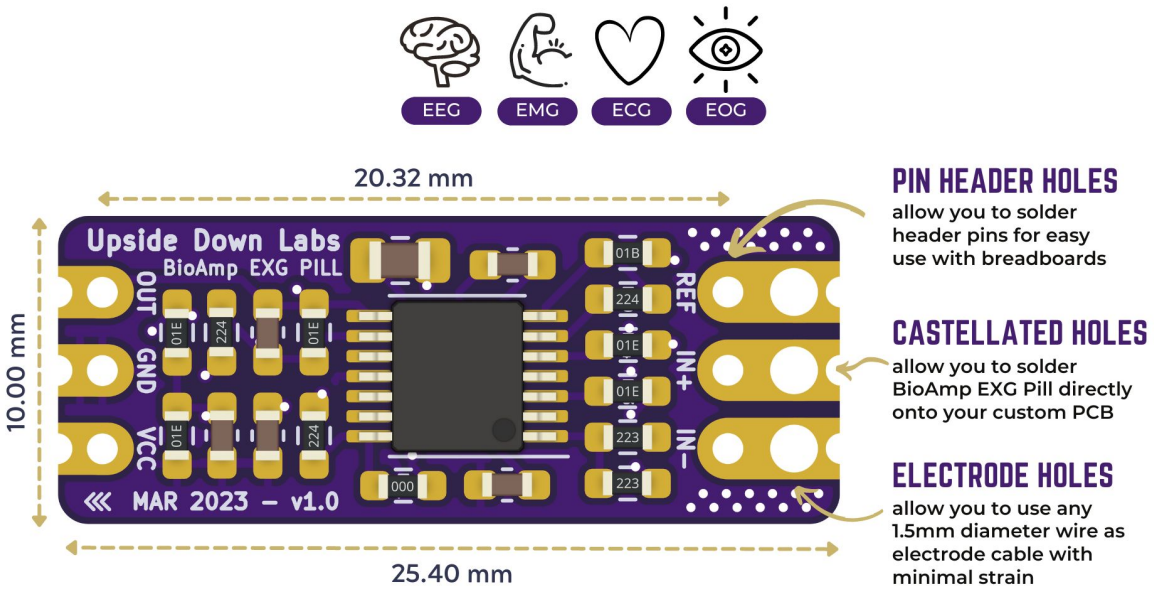
1.4 Board layout

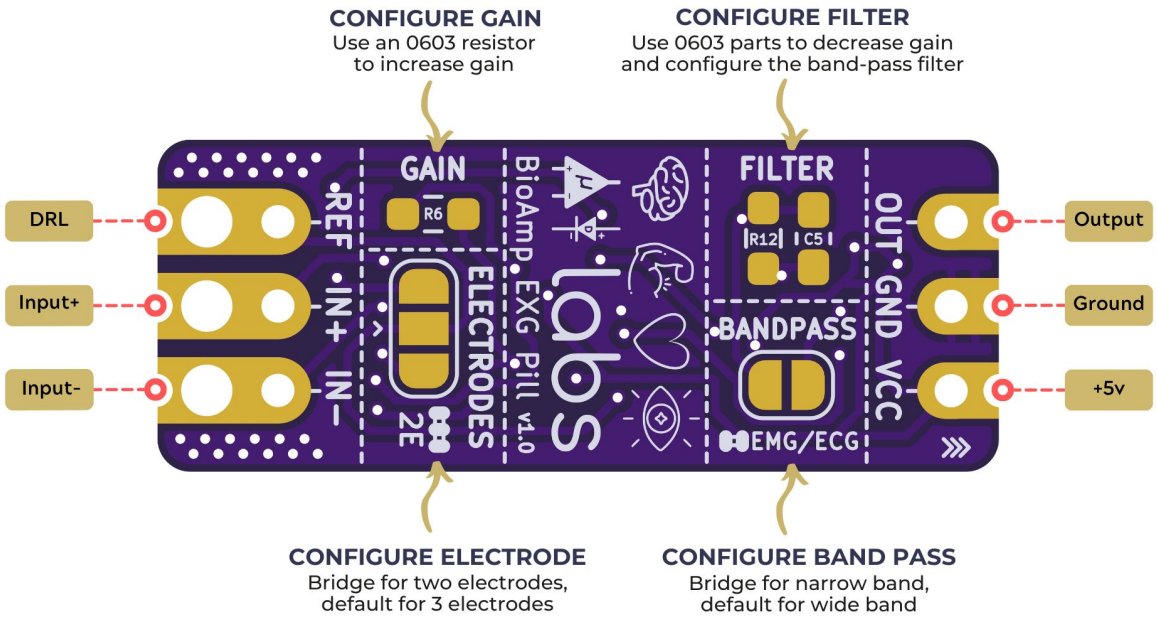
BioAmp EXG Pill's elegant design allows it to be used in 3 ways:

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.

1.4.1 BioAmp EXG Pill is fully configurable

1. Increase the gain of the instrumentation amplifier by using 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


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-
REF
IN+
IN−
GAIN
R6
ELECTRODES
2E
BioAmp EXG Pill v1.0
labs
FILTER
R12
C5
BANDPASS
EMG/ECG
OUT
GND
VCC
Output
Ground
+5v
CONFIGURE ELECTRODE
Bridge for two electrodes, default for 3 electrodes
CONFIGURE BAND PASS
Bridge for narrow band, default for wide band

is specifically included for projects like heart (ECG) patches for HRV. It's only supposed to be used with a 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)

1.5 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 in your development board and visualise the data on your laptop.

- Download Backyard Brains' Spike Recorder according to the operating system you are using (Windows, OSX, Linux).

1.6 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.

1.6.1 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.

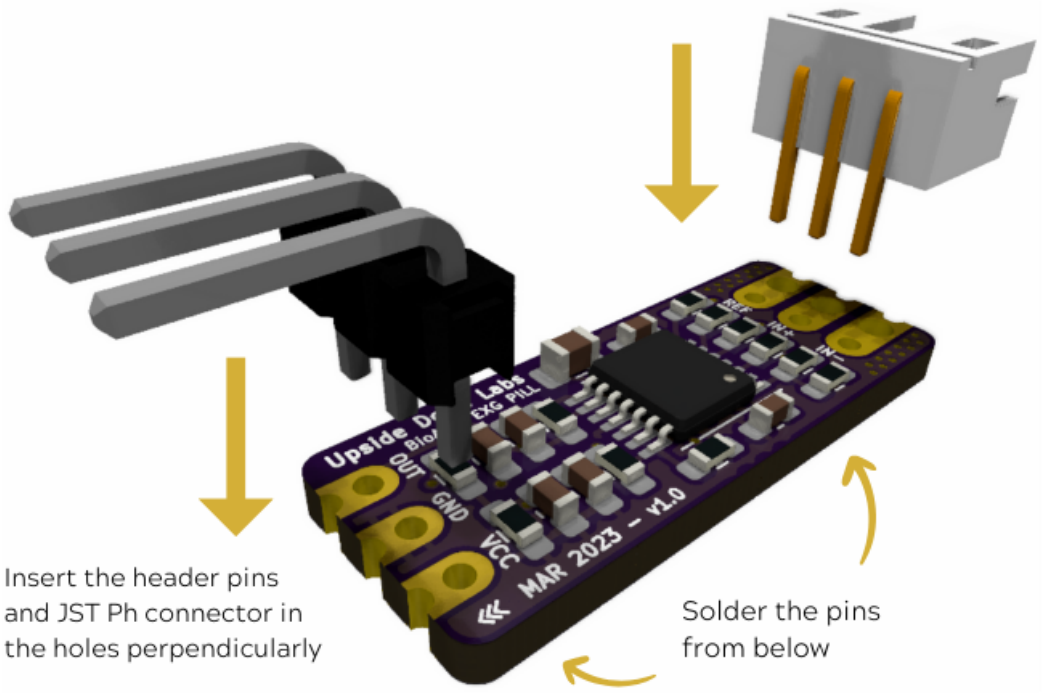


Fig. 1: *Soldering the connector & header pins on BioAmp EXG Pill*

1.6.2 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.

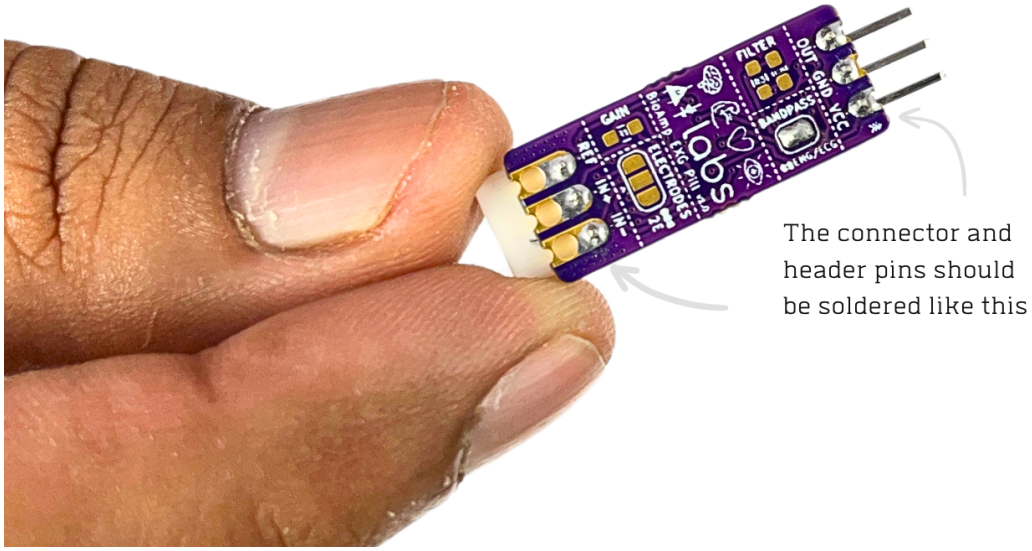
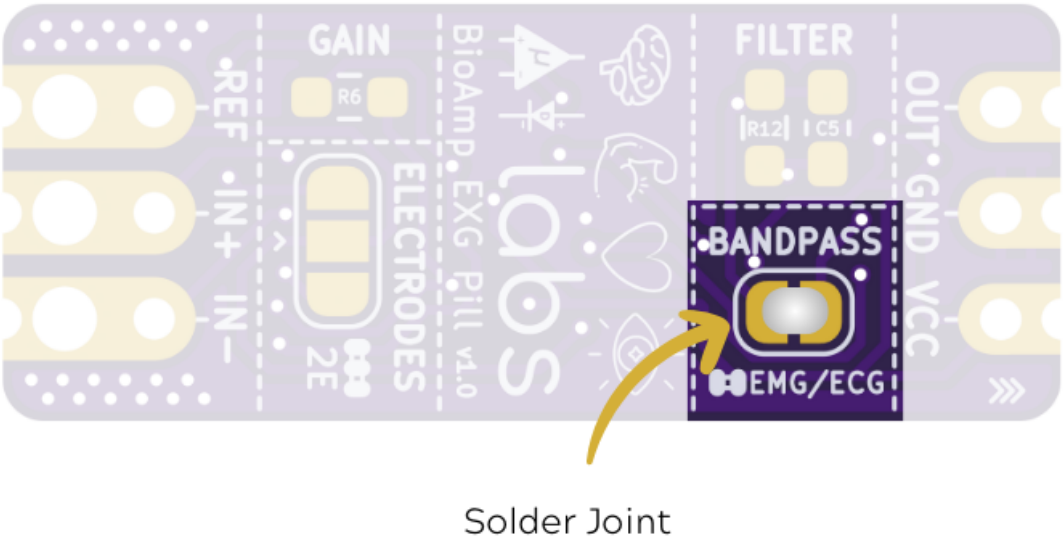


Fig. 2: *After soldering, BioAmp EXG Pill should look like this*



1.6.3 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	5V
GND	GND
OUT	ADC Input

For all the examples provided, we are using the A0 pin of Arduino UNO R3. Connect your BioAmp to your MCU/ADC via jumper cables provided in the kit. If you are connecting `OUT` pin of BioAmp to any other analog pin (A0-A5) of Arduino UNO board, then you will have to change the INPUT PIN in the Arduino sketch accordingly.

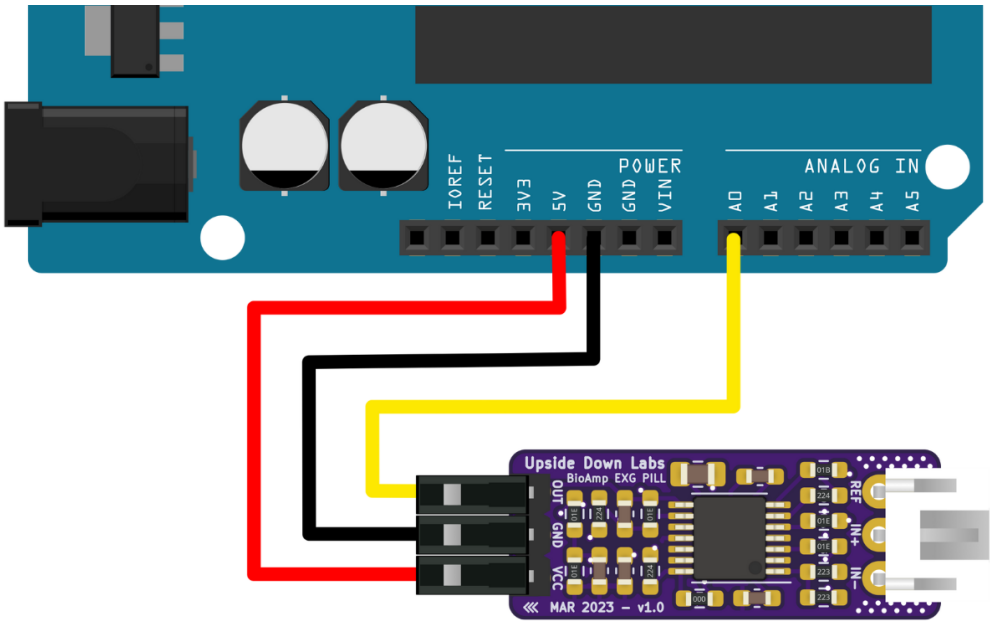


Fig. 3: *Connections with Arduino UNO R3*

Warning

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

1.6.4 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.

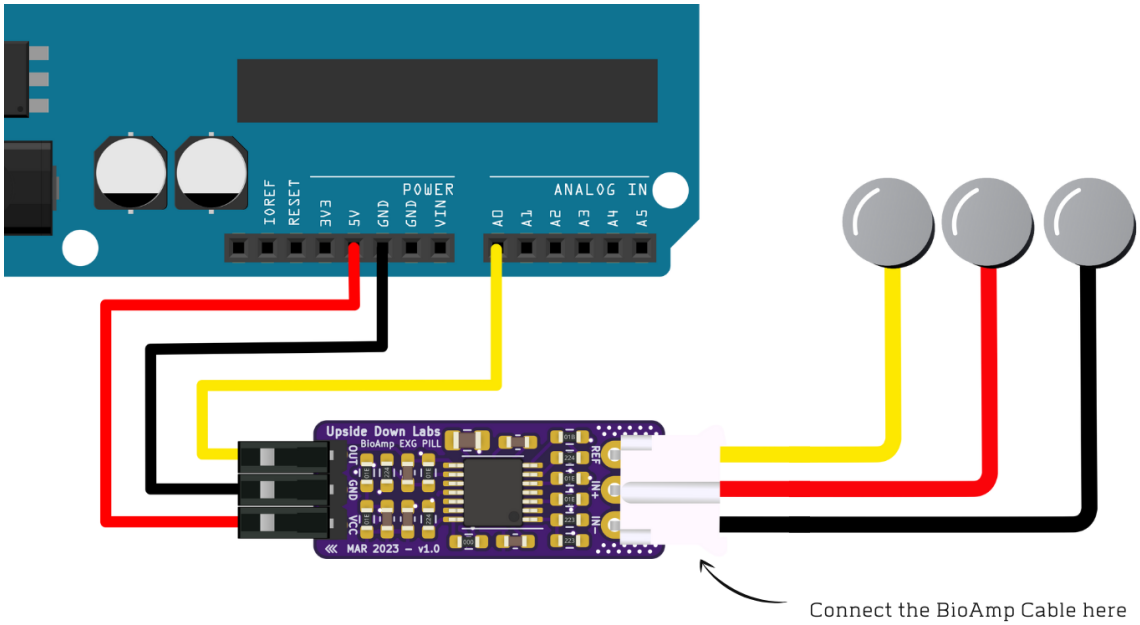


Fig. 4: *Connections with BioAmp Cable v3*

1.6.5 Step 5: 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*.

1.6.6 Step 6: Measuring ElectroMyoGraphy (EMG)

Note

Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is also used as a diagnostic procedure to assess the health of muscles and the nerve cells that control them (motor neurons). EMG results can reveal nerve dysfunction, muscle dysfunction, or problems with nerve-to-muscle signal transmission.

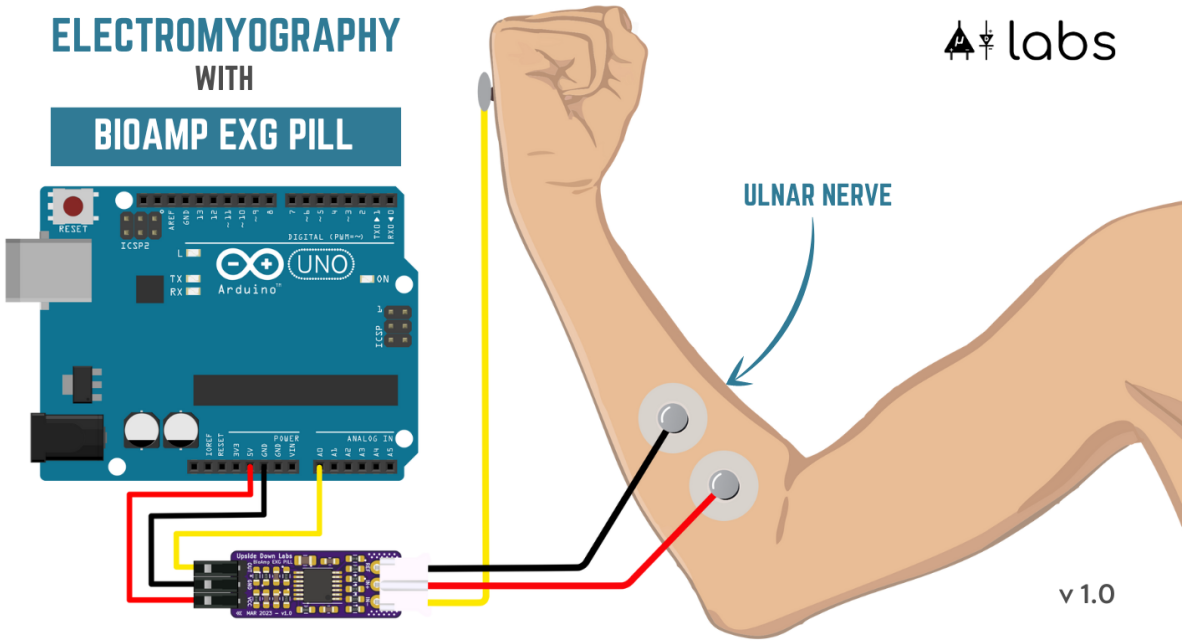
Electrodes placement

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. 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.

- **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.

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.

Uploading the code

Connect the Arduino Uno to your laptop using the USB cable (Type A to Type B). Copy paste any one of the Arduino Sketches given below in Arduino IDE v1.8.19 that you downloaded earlier:

EMG Filter

EMG Envelope

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.

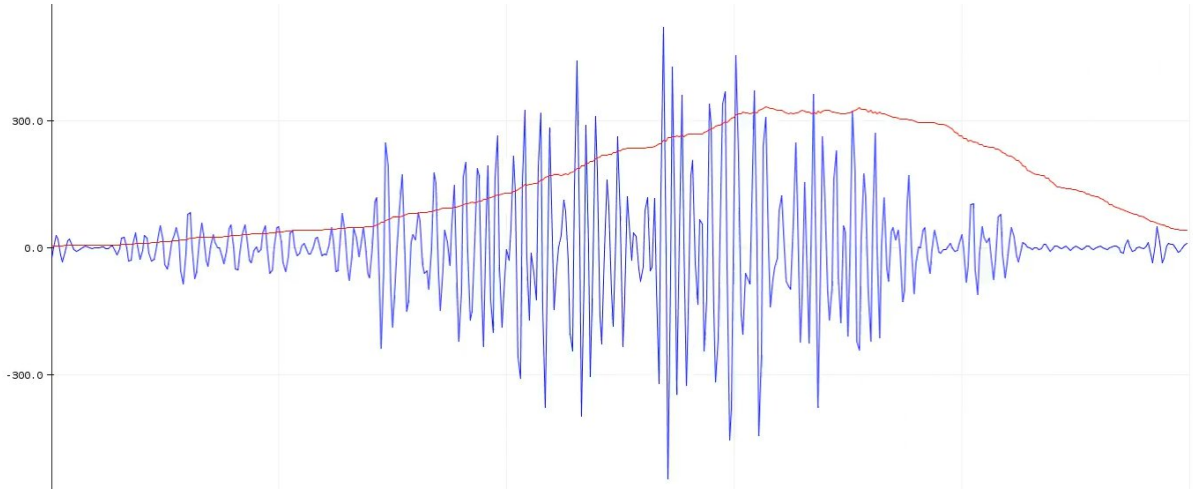
After opening the serial plotter make sure to select the baud rate to 115200.

Important

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

Visualizing the EMG signals

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



1.6.7 Step 6: Measuring ElectroCardioGraphy (ECG)

Note

Electrocardiography (ECG) is the process of producing an electrocardiogram (ECG or EKG). It is a graph of voltage versus time of the electrical activity of the heart using electrodes placed on the skin. These electrodes detect the small electrical changes that are a consequence of cardiac muscle depolarization followed by repolarization during each cardiac cycle (heartbeat).

Electrodes placement

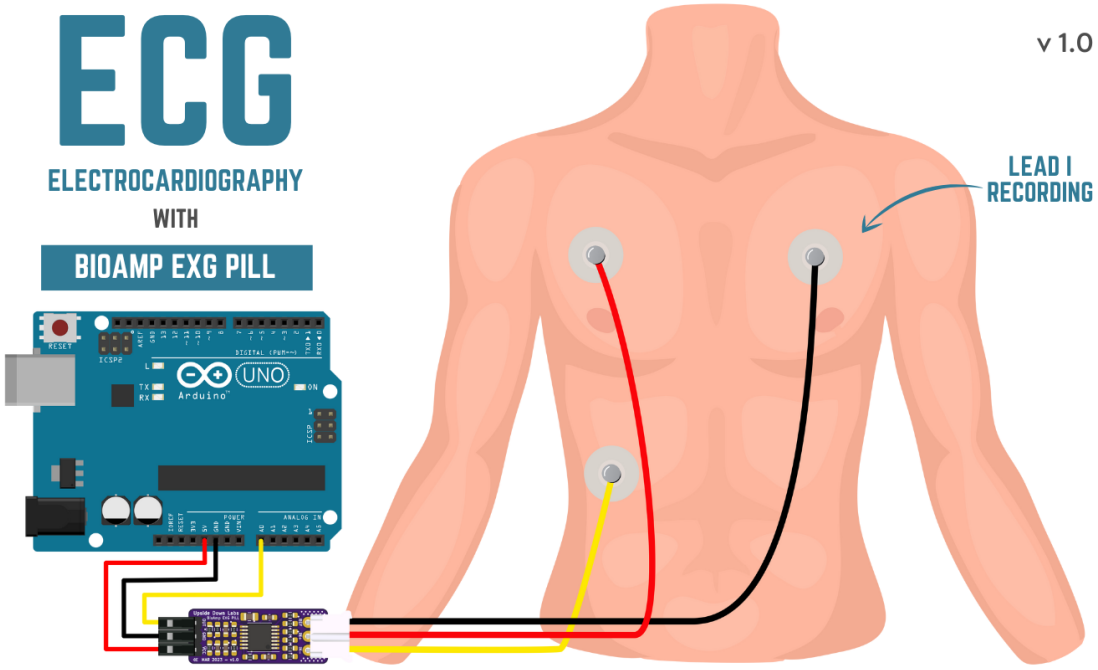
We have 2 options to measure the ECG signals, either using the gel electrodes or using dry electrode based Heart BioAmp Band. You can try both of them one by one.

- **Using gel electrodes:**

1. Connect the BioAmp cable to gel electrodes
2. Peel the plastic backing from electrodes
3. Place the IN- cable on the left side, IN+ in the middle and REF (reference) on the far right side as shown in the diagram.

- **Using Heart BioAmp Band:**

1. Wear the band as depicted in the video tutorial given below
2. Place the IN- cable on the left side, IN+ in the middle and REF (reference) on the far right side.



3. Now put a small drop of electrode gel between the skin and metallic part of BioAmp cable to get the best results.

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/fr5iORsVyUM

Uploading the code

Connect Arduino Uno to your laptop using the USB cable (Type A to Type B). Copy paste the Arduino Sketch given below in Arduino IDE v1.8.19 that you downloaded earlier:

ECG Filter

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 signals.

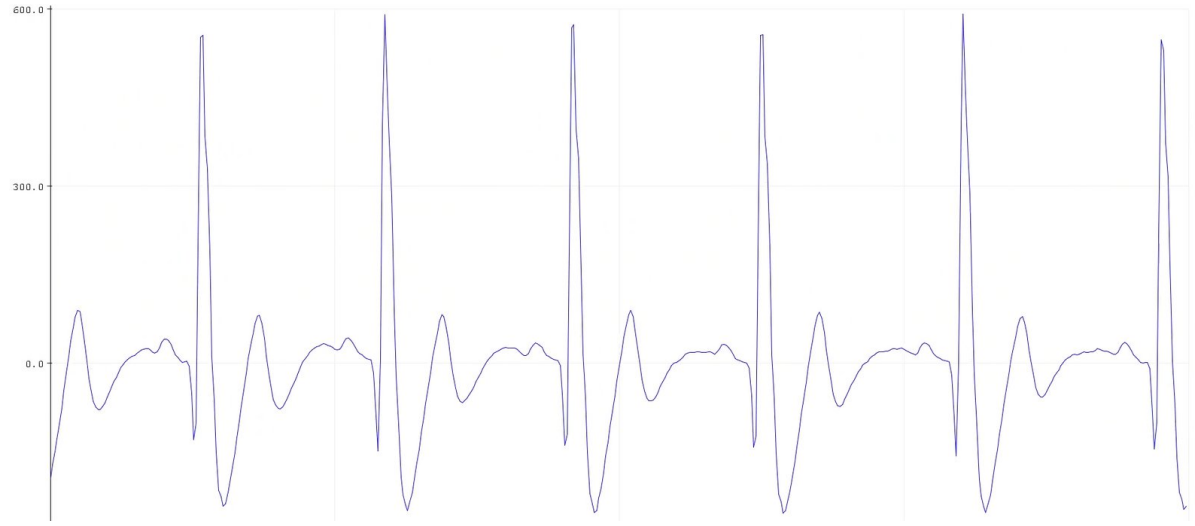
After opening the serial plotter make sure to select the baud rate to 115200.

Important

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

Visualizing the ECG signals

Sit back, relax and see your ECG signals in real time on your laptop.



1.6.8 Step 7: Measuring Electrooculography (EOG)

Note

Electrooculography (EOG) is a technique for measuring the corneo-retinal standing potential that exists between the front and the back of the human eye. The resulting signal is called EOG. To measure eye movement, pairs of electrodes are typically placed either above and below the eye or to the left and right of the eye. If the eye moves from the center position toward one of the two electrodes, this electrode "sees" the positive side of the retina, and the opposite electrode "sees" the negative side of the retina. Consequently, a potential difference occurs between the electrodes. Assuming the resting potential is constant, the recorded potential is a measure of the eye's position.

Electrodes placement

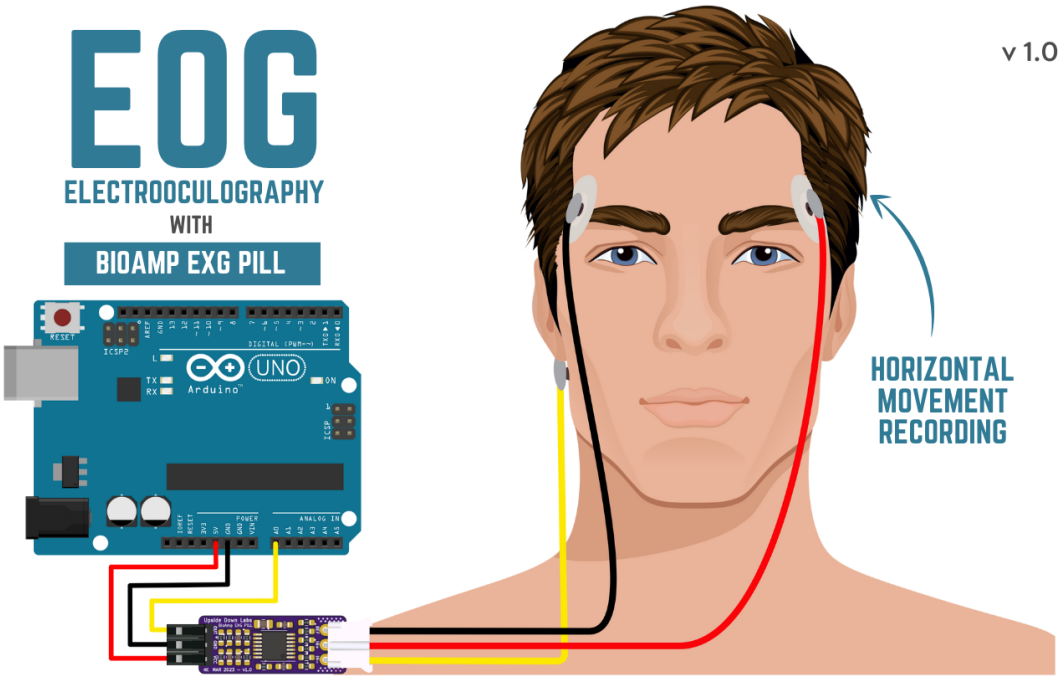
We have 2 ways to measure the EOG signals, either record the horizontal eye movement or the vertical eye movement. You can one by one record both the signals.

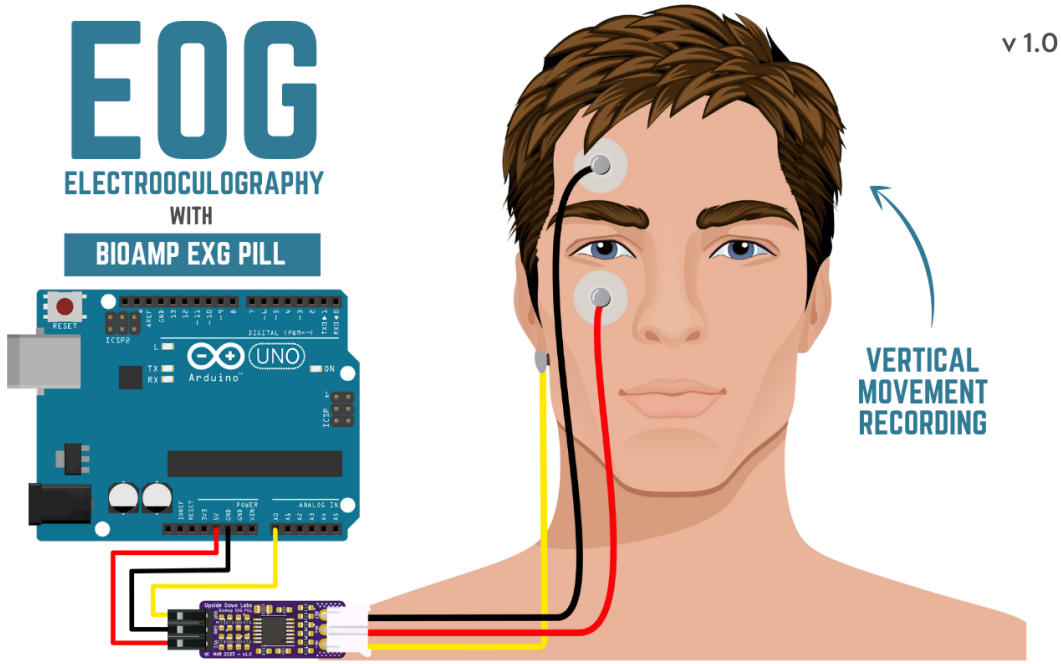
- **Horizontal EOG recording:**

1. Connect the BioAmp cable to gel electrodes.
2. Peel the plastic backing from electrodes.
3. Place the IN- cable on the right side of the eye, IN+ on the left side of the eye and REF (reference) at the bony part, on the back side of your earlobe as shown in the diagram above.

- **Vertical EOG recording:**

1. Connect the BioAmp cable to gel electrodes.
2. Peel the plastic backing from electrodes.
3. Place the IN- & IN+ cables above and below the eye respectively and REF (reference) at the bony part, on the back side of your earlobe as shown in the diagram above.


EOG
ELECTROOCULOGRAPHY
WITH
BIOAMP EXG PILL
v 1.0
HORIZONTAL
MOVEMENT
RECORDING


EOG
ELECTROOCULOGRAPHY
WITH
BIOAMP EXG PILL
v 1.0
VERTICAL
MOVEMENT
RECORDING

Uploading the code

Connect Arduino Uno to your laptop using the USB cable (Type A to Type B). Copy paste the Arduino Sketch given below in Arduino IDE v1.8.19 that you downloaded earlier:

EOG Filter

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 signals.

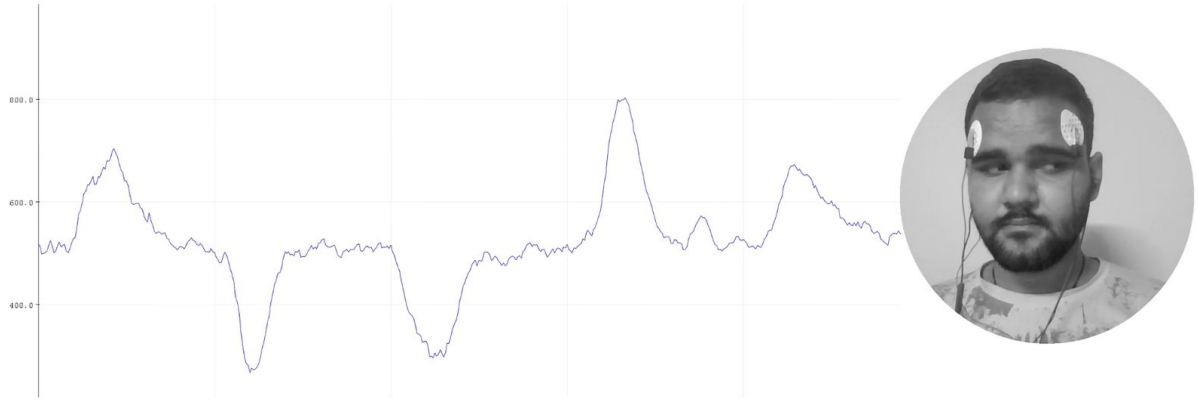
After opening the serial plotter make sure to select the baud rate to 115200.

Important

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

Visualizing the EOG signals

Move your eyes up-down or left-right to see your EOG signals in real time on your laptop.



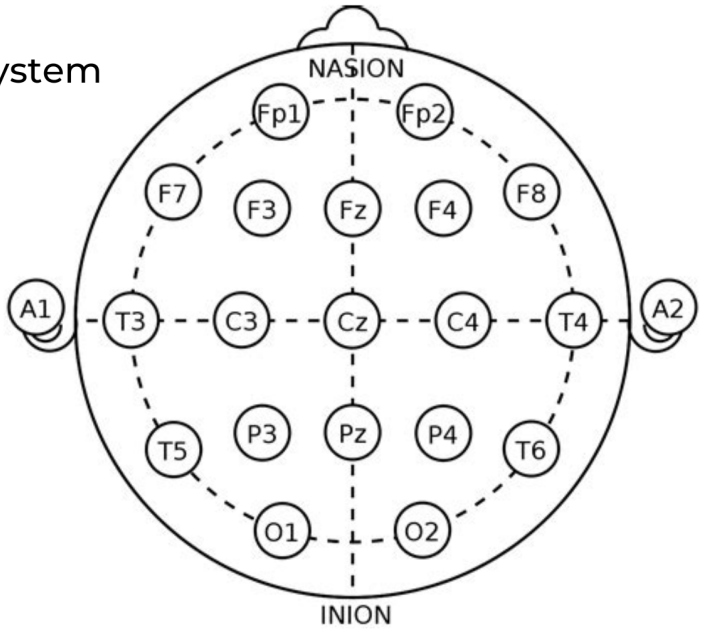
1.6.9 Step 8: Measuring Electroencephalography (EEG)

Note

Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity on the scalp. During the procedure, electrodes consisting of small metal discs with thin wires are pasted onto your scalp. The electrodes detect tiny electrical charges that result from the activity of your brain cells which are then amplified to appear on the computer screen. It is typically non-invasive, with the electrodes placed along the scalp.

For recording EEG from different parts of the brain, you have to place the electrodes according to the International 10-20 system for recording EEG.

International 10-20 system for recording EEG

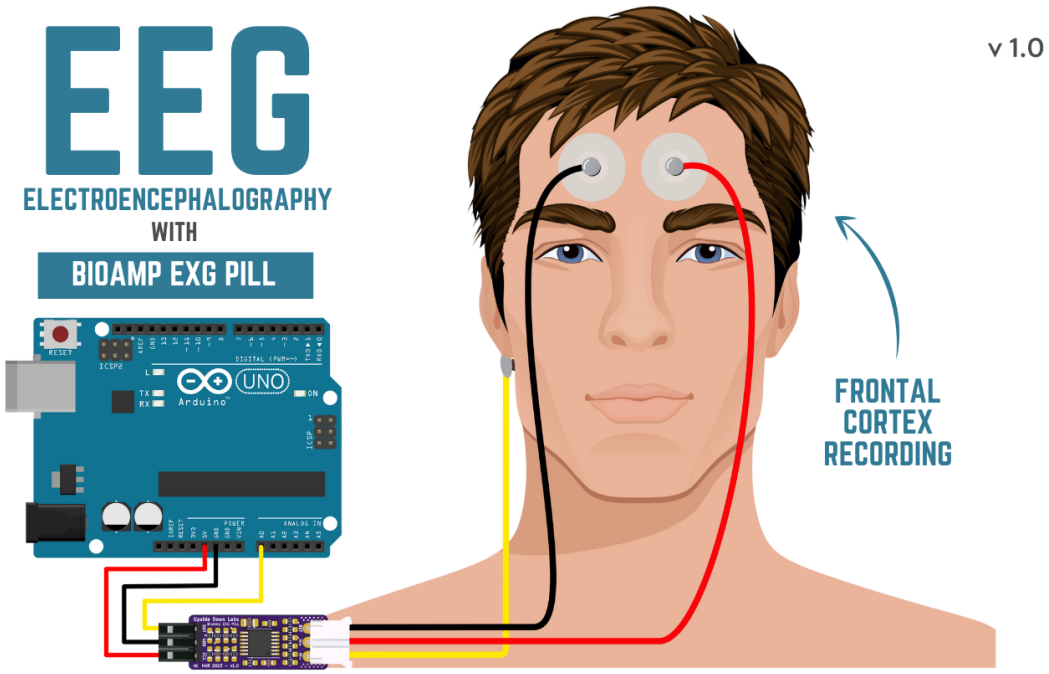


Source: Wikipedia

Electrodes placement

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

- **Using gel electrodes to record from prefrontal cortex part of brain:**



1. Connect the BioAmp cable to gel electrodes.
2. Peel the plastic backing from electrodes.
3. Place the IN+ and IN- cables on Fp1 and Fp2 as per the International 10-20 system & REF (reference) at the bony part, on the back side of your earlobe as shown above.

- **Using Brain BioAmp Band to record from prefrontal cortex part of brain:**

1. Connect the BioAmp cable to Brain BioAmp Band in a way such that IN+ and IN- are placed on Fp1 and Fp2 as per the International 10-20 system.
2. In this case, the REF (reference) should be connected using gel electrode. So connect the reference of BioAmp cable to the gel electrode, peel the plastic backing and place it at the bony part, on the back side of your earlobe.
3. Now put a small drop of electrode gel on the dry electrodes (IN+ and IN-) between the skin and metallic part of BioAmp cable to get the best results.

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/O6qp7teT-sM

Note

Similarly you can use the band to record EEG signals from the visual cortex part of brain by placing the dry electrodes on O1 and O2 instead of Fp1 and Fp2. Everything else will remain the same.

Uploading the code

Connect Arduino Uno to your laptop using the USB cable (Type A to Type B). Copy paste the Arduino Sketch given below in Arduino IDE v1.8.19 that you downloaded earlier:

Spike recorder arduino code

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 development board is connected. To find out the right COM port, screen disconnect your 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.

Visualizing the EEG signals

Open the Spike Recorder software. When the Spike Recorder starts, it will start recording from your microphone. To change that, go to the settings by clicking the first icon on the top left corner of the screen, select the COM port on which your Arduino UNO is connected and click on connect.

Mute the speakers and apply the 50Hz notch filter by clicking on the checkbox as shown in the screenshot above. You should set the low band pass filter to 1Hz and high bandpass filter to 40Hz as we are only recording the EEG signals which range between these frequencies.

Now everything is configured and connected. So close the settings window and start recording EEG signals.

The signals that you can see on the screen right now are originating from prefrontal cortex part of your brain and propagating through all the layers to the surface of your skin.

To record these EEG signals, you have placed the electrodes on the forehead (Fp1 & Fp2), then BioAmp EXG Pill is amplifying those signals so that we can detect it and finally sending it to the ADC (Analog to Digital Convertor) of your Arduino Uno. Ultimately the signals are being visualized in Spike Recorder software.

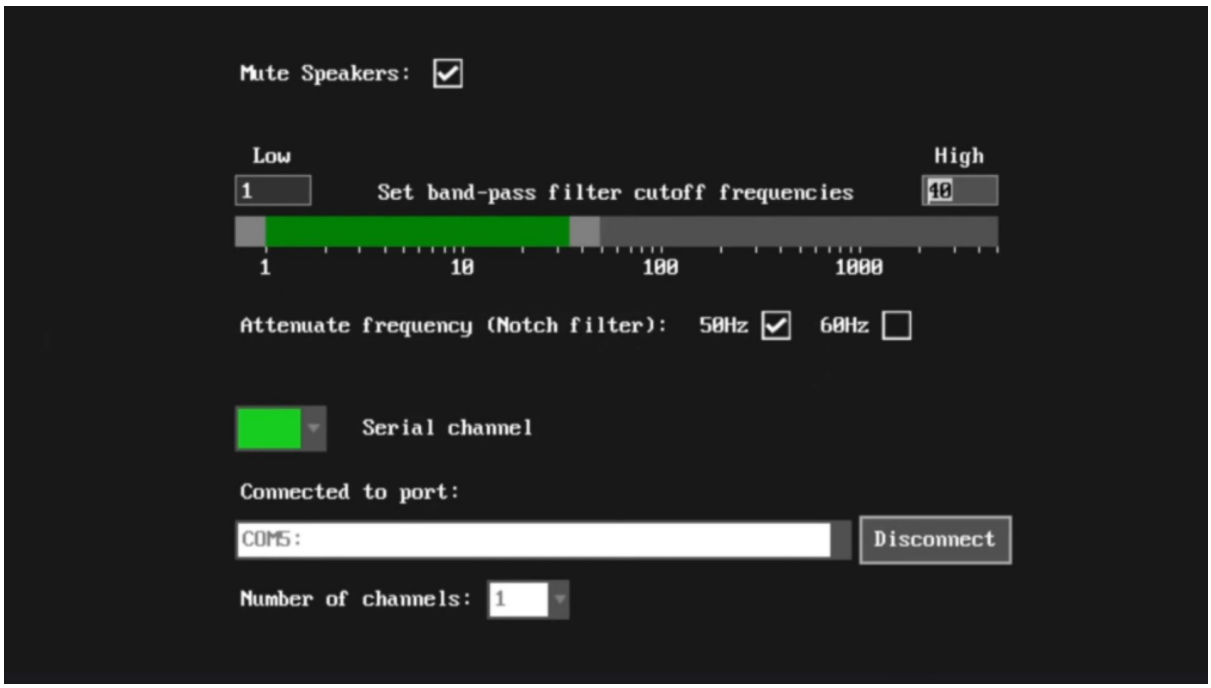


Fig. 5: *Spike Recorder settings*

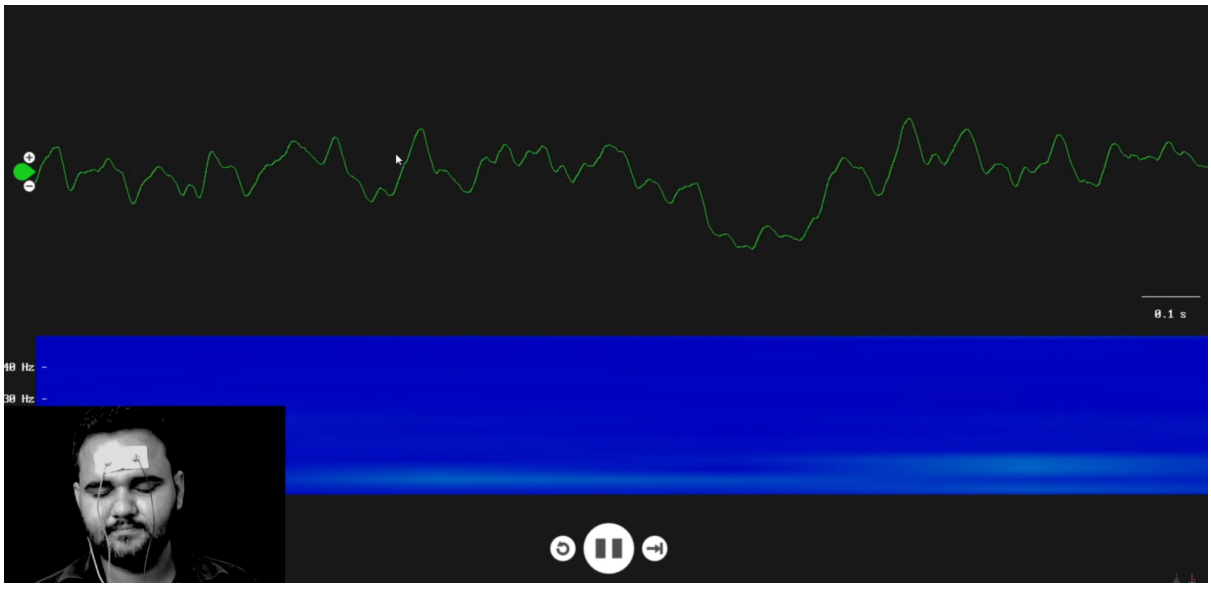


Fig. 6: *EEG signals being visualised in Spike Recorder*

We hope everything is clear now and you understand how the signals are propagating from your brain to the screen of the laptop.

Features of Spike Recorder that you can explore:

- Increase or decrease the scale of the Y axis by clicking on the + and - icons respecitively that is present on the left side of the graph.
- Increase or decrease the X axis timescale by sliding up and down on the scroll wheel of the mouse.
- Visualize the FFT graph by clicking on the FFT icon on top left size of the screen.
- Record the data in .wav format by clicking the record icon on the top right corner. You can convert this data in any other format according to your project requirements.
- Listen to the signals by clicking the volume icon on the top right corner. No don't smile right now, that's how your brain sounds like :P

1.7 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

1.8 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.

1.9 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

1.10 Software tutorials

1. Getting started with Backyard Brains' Spike Recorder

https://youtu.be/QzZh243-Ac8

2. Getting started with Brainbay

https://youtu.be/8vKYAg9C8Jg

CHAPTER

TWO

SKIN PREPARATION GUIDE

2.1 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.

2.2 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.

2.3 Steps to follow

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

2.3.1 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.

2.3.2 Step 2: Apply NuPrep gel

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

2.3.3 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.

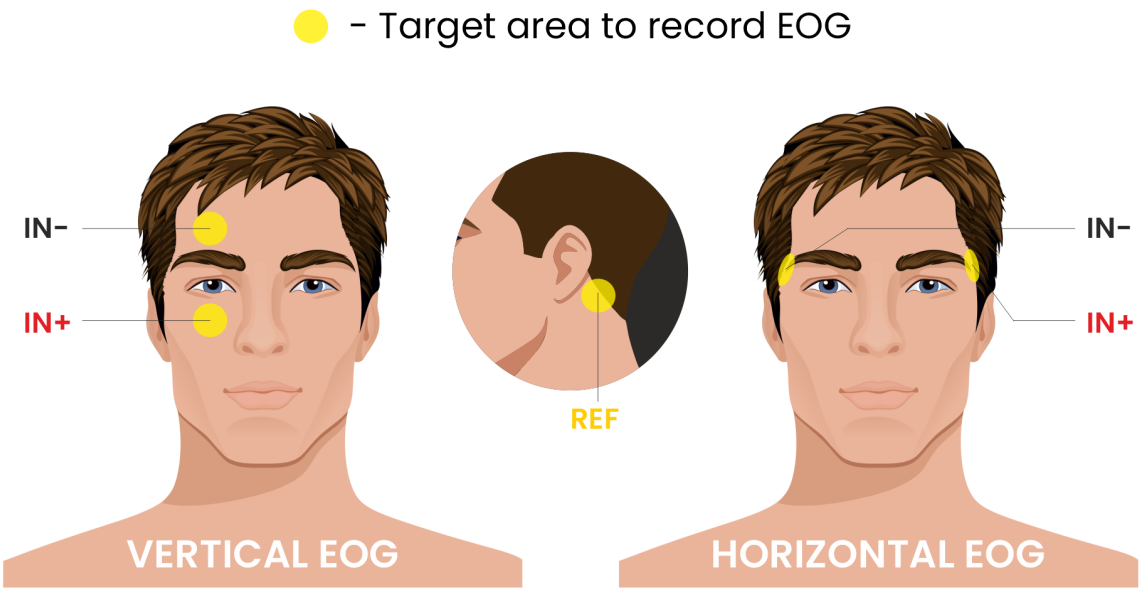


Fig. 1: Target area to record EOG

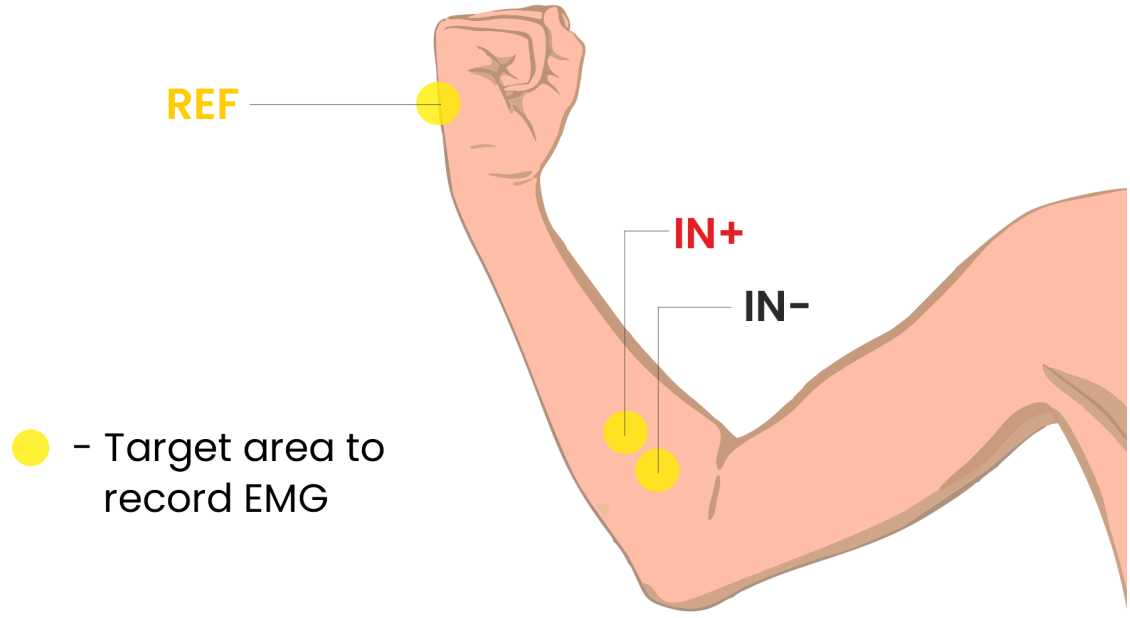


Fig. 2: Target area to record EMG

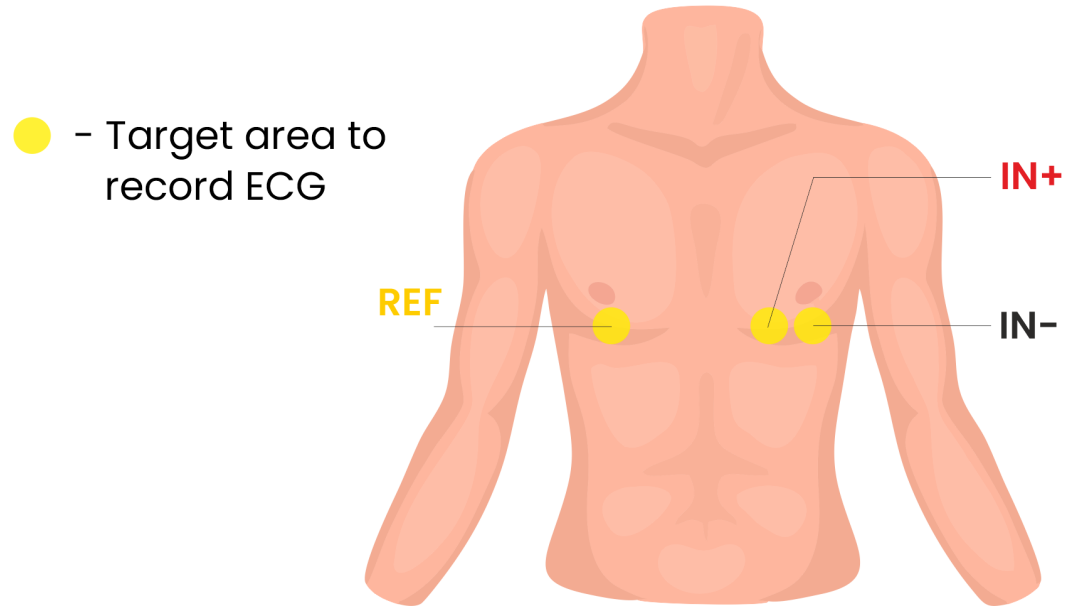


Fig. 3: Target area to record ECG

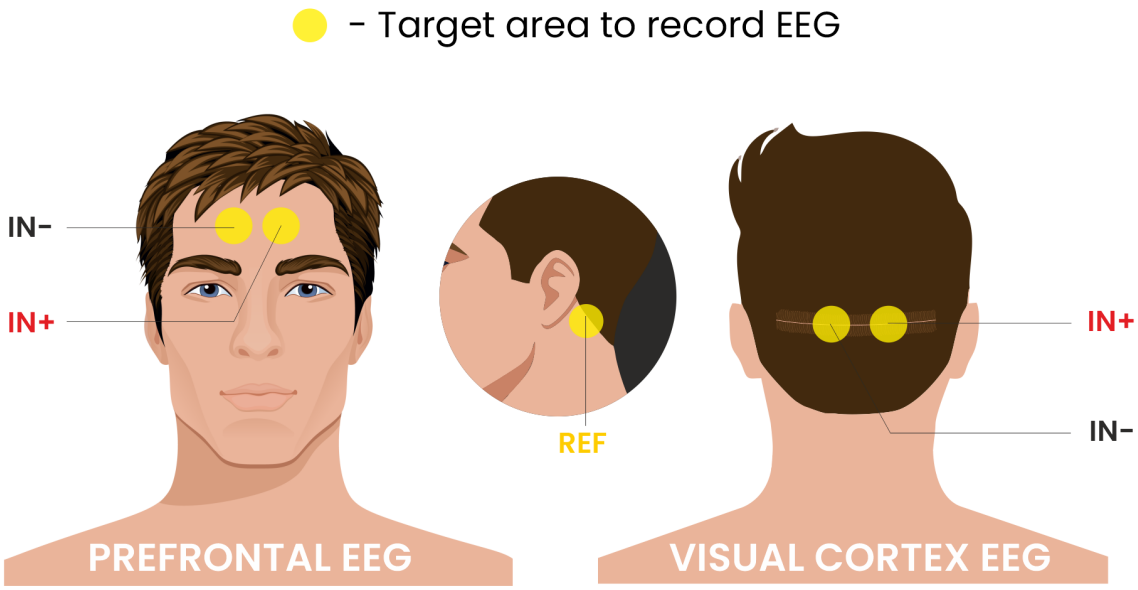
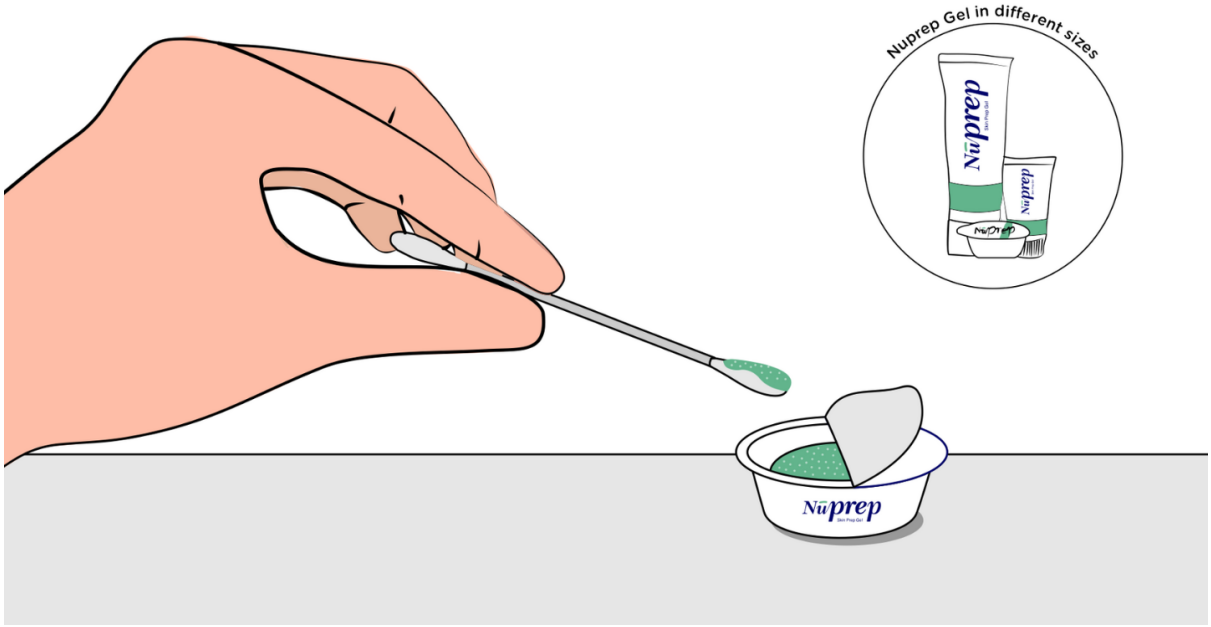


Fig. 4: Target area to record EEG



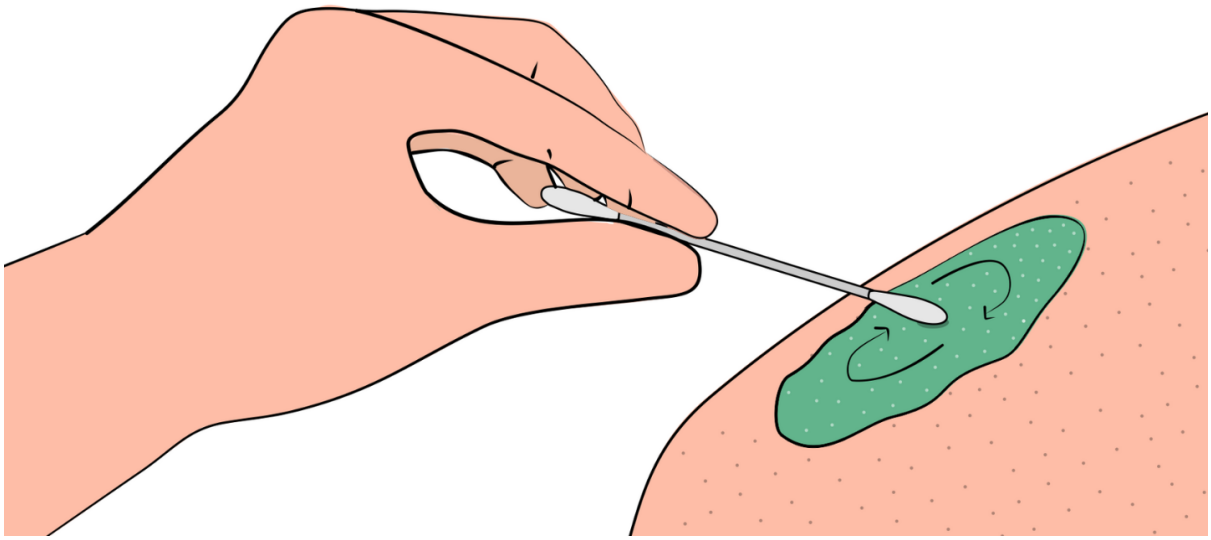


Fig. 5: Rub the gel gently using the cotton swab

2.3.4 Step 4: Wipe off the gel

Wipe away excess gel with alcohol swabs or wet wipes.

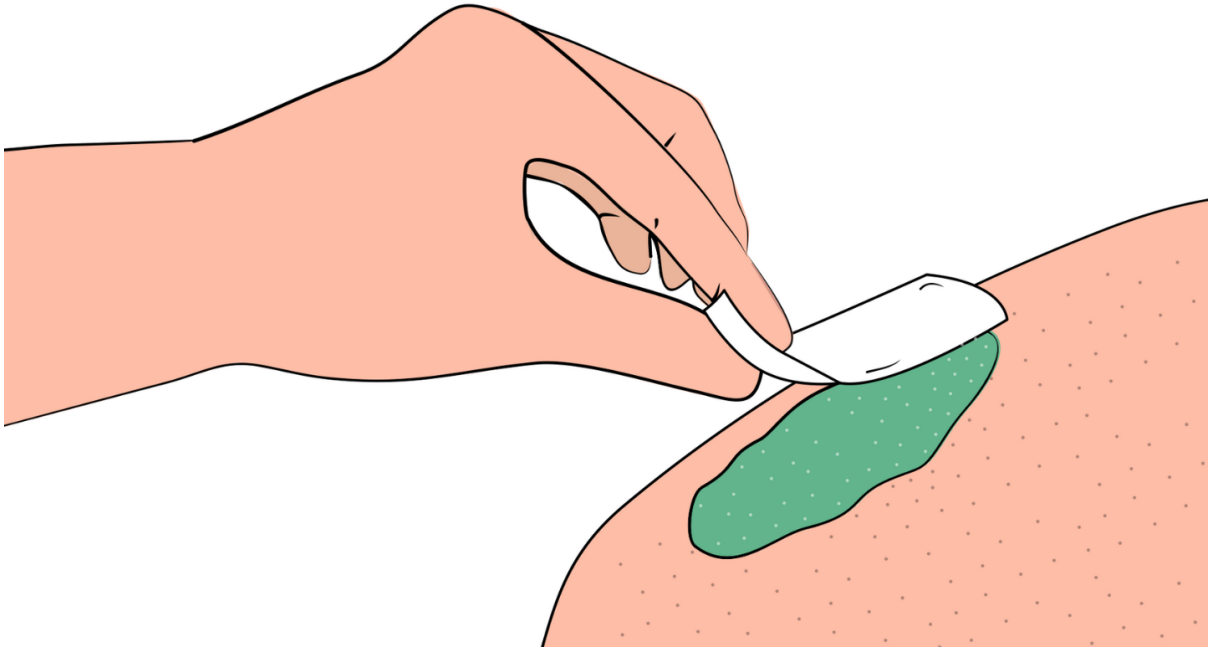


Fig. 6: Wipe away access gel

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.

2.3.5 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.

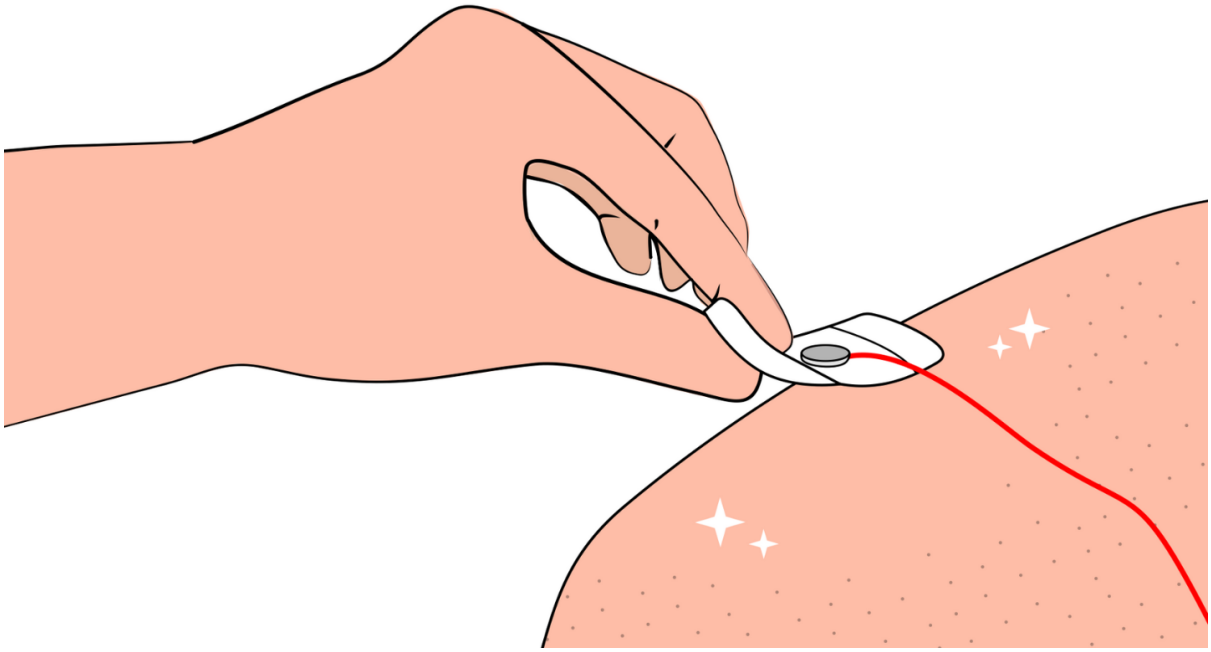


Fig. 7: Placing gel electrodes on skin surface

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.

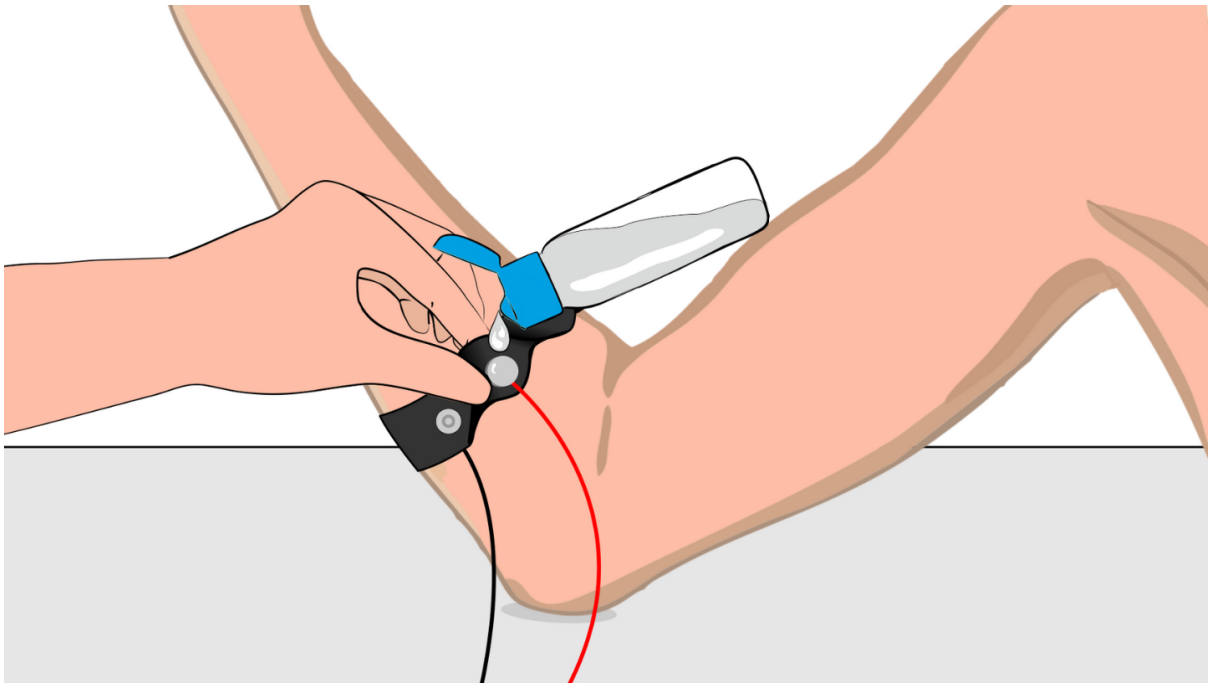


Fig. 8: Method 1: Using Electrode gel

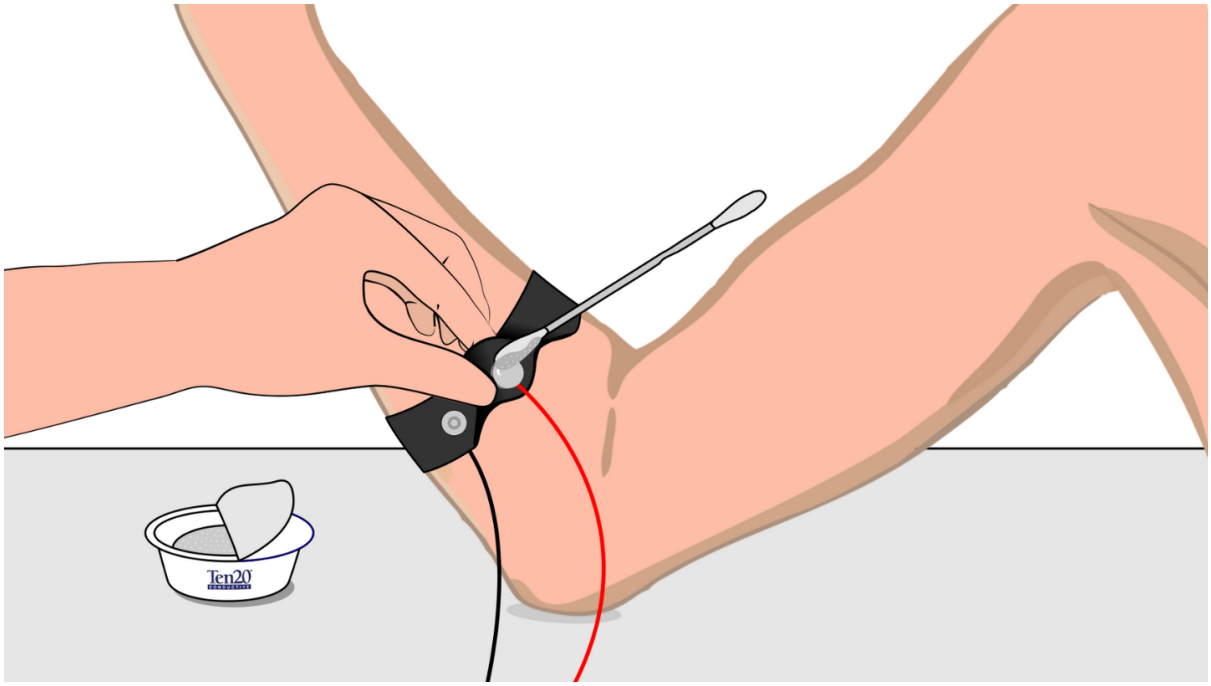


Fig. 9: Method 2: Using Ten20 paste