

---

# **BioAmp EXG Pill**

**Upside Down Labs**

**Aug 02, 2024**

# CONTENTS

<b>1 BioAmp EXG Pill</b>	<b>1</b>
1.1 Overview . . . . .	1
1.2 What makes it different? . . . . .	2
1.3 Features & Specifications . . . . .	2
1.4 Board layout . . . . .	2
1.4.1 BioAmp EXG Pill is fully configurable . . . . .	2
1.5 Software requirements . . . . .	4
1.6 Using the Hardware . . . . .	5
1.6.1 Step 1: Solder Connectors . . . . .	5
1.6.2 Step 2 (optional): Configure for ECG/EMG . . . . .	5
1.6.3 Step 3: Connect MCU/ADC . . . . .	7
1.6.4 Step 4: Connecting electrode cable . . . . .	7
1.6.5 Step 5: Skin Preparation . . . . .	8
1.6.6 Step 6: Measuring ElectroMyoGraphy (EMG) . . . . .	8
1.6.7 Step 6: Measuring ElectroCardioGraphy (ECG) . . . . .	10
1.6.8 Step 7: Measuring Electrooculography (EOG) . . . . .	12
1.6.9 Step 8: Measuring Electroencephalography (EEG) . . . . .	14
1.7 Glimpses of previous versions . . . . .	18
1.8 Real-world Applications . . . . .	18
1.9 Project ideas & tutorials . . . . .	18
1.10 Software tutorials . . . . .	19
<b>2 Skin Preparation Guide</b>	<b>20</b>
2.1 Why skin preparation is important? . . . . .	20
2.2 Kit Contents . . . . .	20
2.3 Steps to follow . . . . .	21
2.3.1 Step 1: Identify the targeted area . . . . .	21
2.3.2 Step 2: Apply NuPrep gel . . . . .	21
2.3.3 Step 3: Clean the skin surface . . . . .	21
2.3.4 Step 4: Wipe off the gel . . . . .	25
2.3.5 Step 5: Measuring the signals . . . . .	25
<b>3 Using BioAmp Bands</b>	<b>28</b>
3.1 Overview . . . . .	28
3.2 Why use BioAmp Bands? . . . . .	28
3.3 Types of BioAmp Bands . . . . .	28
3.3.1 1. Muscle BioAmp Band . . . . .	29
3.3.2 2. Heart BioAmp Band . . . . .	29
3.3.3 3. Brain BioAmp Band . . . . .	30
3.4 Using Muscle BioAmp Band . . . . .	31
3.4.1 Assembly . . . . .	31
3.4.2 Skin Preparation . . . . .	33
3.4.3 Measure EMG . . . . .	33
3.5 Using Heart BioAmp Band . . . . .	35

3.5.1	Skin Preparation . . . . .	35
3.5.2	Assembly . . . . .	35
3.5.3	Measure ECG . . . . .	37
3.6	Using Brain BioAmp Band . . . . .	38
3.6.1	Assembly . . . . .	38
3.6.2	Skin Preparation . . . . .	38
3.6.3	Measure 1-channel EEG . . . . .	38

---

**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



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.

### Legacy IDE (1.8.X)

The screenshot shows the official Arduino website's download page for the IDE. At the top, there's a large button for "Arduino IDE 1.8.19". Below it, a brief description explains that the open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It can be used with any Arduino board. A link to the "Arduino IDE 1.x documentation" is provided for installation instructions. On the right side, there's a "DOWNLOAD OPTIONS" section with links for Windows (Win 7 and newer), Windows ZIP file, Windows app (Get it), Linux (32 bits, 64 bits, ARM 32 bits, ARM 64 bits), Mac OS X (10.10 or newer), Release Notes, and Checksums (sha512). There's also a note about PGP-signed source code archives.

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

The screenshot shows the BYB Spike Recorder software landing page. It features a large orange button with a brain icon labeled "BYB Spike Recorder". Below it, a text block says: "Now you can record data straight to your laptop or computer! The BYB Spike Recorder turns your PC into a high-tech data recording and analysis tool." To the left, there's a "Documents" section with links to "PC Documentation", "iOS Documentation", and "Tutorial: Using Spike Recorder with". On the right, there's a "Recording Spikes" section with a description of the software's functionality. At the bottom right, there's a "Free!" button and a list of supported platforms: Windows, OSX, Linux, and Arduino.

## 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:**

## ELECTROMYOGRAPHY WITH BIOAMP EXG PILL



labs

ULNAR NERVE

v 1.0

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/xYZdw0aes0>

### 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.



- 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

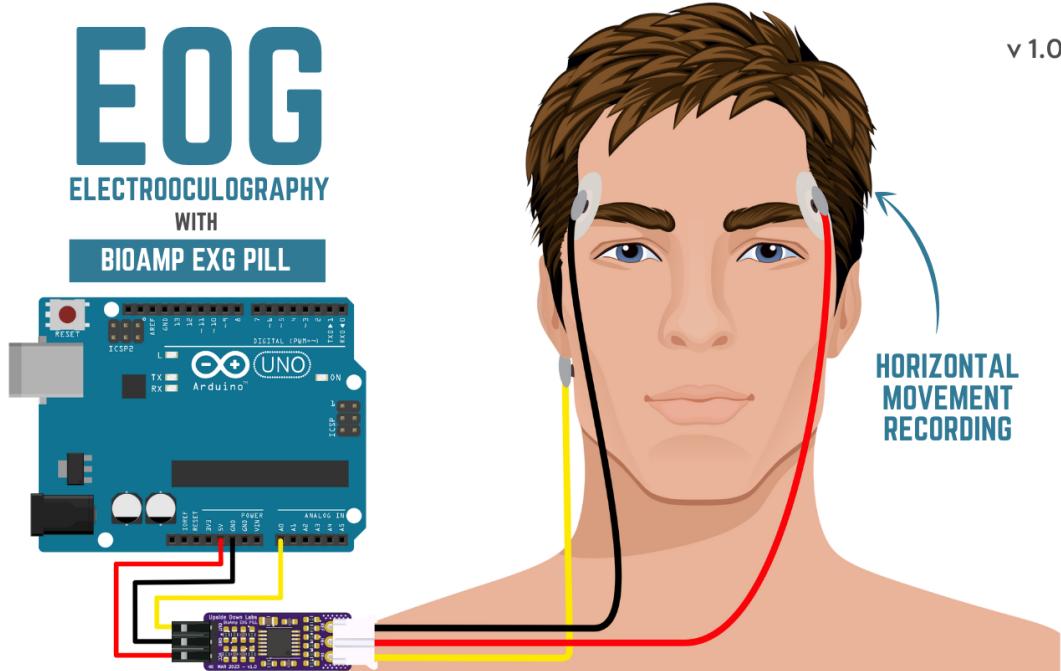
We have 2 ways to measure the EOG signals, either record the horizontal eye movement or the vertical eye movement. You can one by one record both the signals.

- **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.



### 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 respectively 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](mailto: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.

# Contents of the kit



NuPrep Gel



Cotton Swabs



Electrode Gel



Alcohol Swabs



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.

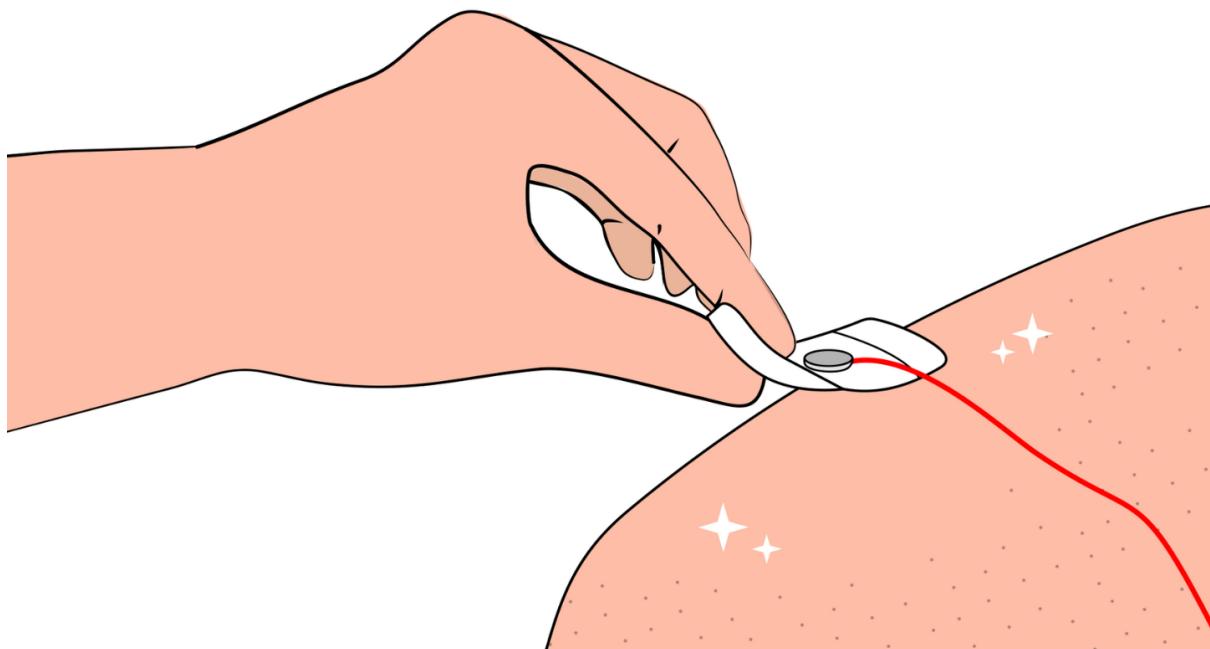


Fig. 7: Placing gel electrodes on skin surface

### 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

## USING BIOAMP BANDS

### 3.1 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.

### 3.2 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 impedance is increasing, then reapply electrode gel frequently. The other option is to use gel electrodes after preparing the skin properly.

### 3.3 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.

### 3.3.1 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

### 3.3.2 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

### 3.3.3 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.



## **3.4 Using Muscle BioAmp Band**

### **3.4.1 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





### 3.4.2 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](#).

### 3.4.3 Measure EMG

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



## BioAmp EXG Pill

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.

## 3.5 Using Heart BioAmp Band

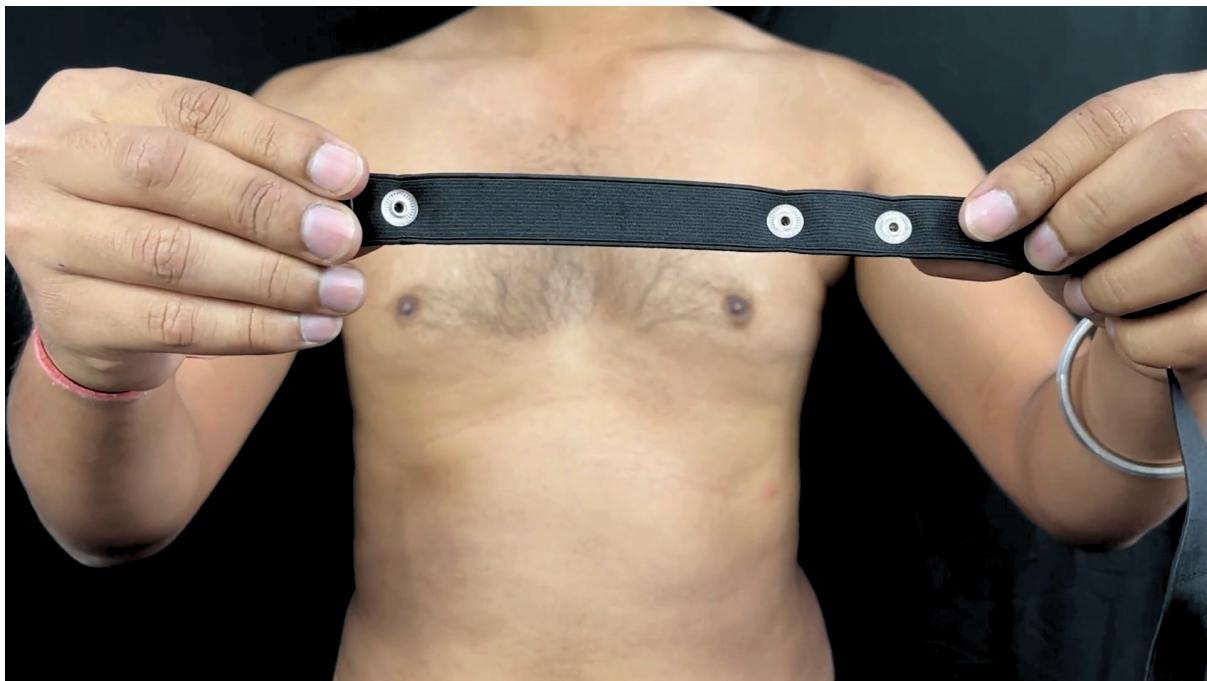
### 3.5.1 Skin Preparation

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](#).

### 3.5.2 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.



### 3.5.3 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.

## 3.6 Using Brain BioAmp Band

### 3.6.1 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.

### 3.6.2 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](#).

### 3.6.3 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 system 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 off 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.