biosignalsplux

Electroencephalography (EEG) Sensor User Manual
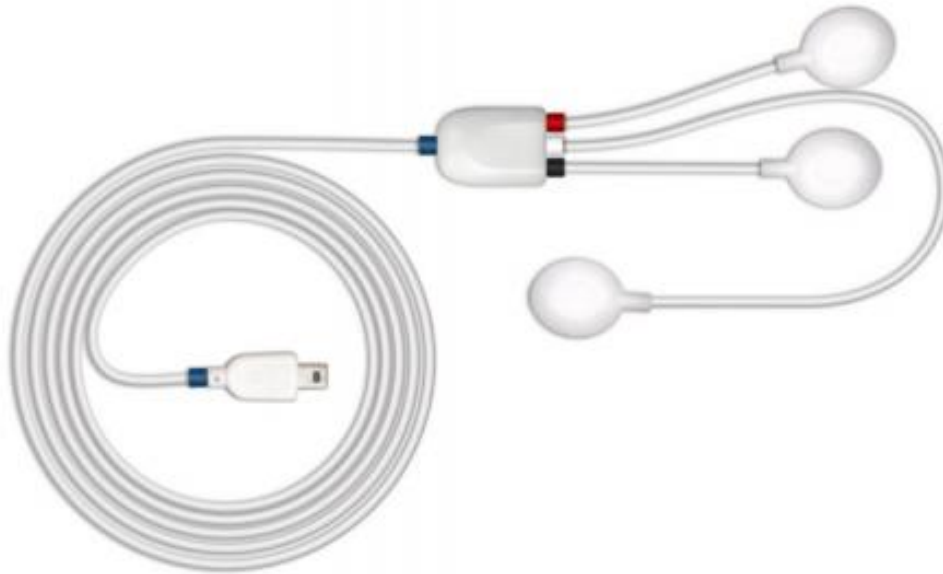
ATTENTION
Please read this datasheet before
using your biosignalsplux sensor

The information contained in this document has been carefully checked and were made every effort to ensure its quality. PLUX reserves the right to make changes and improvements to this manual and products referenced at any time without notice.

The word Bluetooth and its logo are trademarks of Bluetooth SIG Inc. and any use of such marks is under license. Other trademarks are the property of their respective own.

Please check your systems and sensors after receiving and before using it the first time to confirm if it contains all the ordered sensors, accessories and other components. Contact our support via e-mail at support@plux.info if there are any variations from your original order.

For regulatory information, please see the Regulatory Disclaimer at the end of this document.

TABLE OF CONTENTS

1. General Information

1.1. General Description

Our electroencephalography (EEG) sensor has been especially designed for both classic and localized EEG measurement. When a cap is too intrusive, only a limited number of channels are needed. The bipolar configuration, with two measurement electrodes detects the electrical potentials in the specific scalp region with respect to a reference electrode, which should be placed in a region of low muscular activity. The resulting signal is the amplified difference between these two signals, eliminating the common unwanted signals detected by the surfaces. Its convenient form factor enables a discrete placement in regions such as the forehead, occipital, and others.

This sensor can be used to extract neural activations of specific brain regions as well as other EEG features, enabling its application in research fields such as neurophysiology, neurofeedback, psychophysiology, and human-computer interaction, among many others.
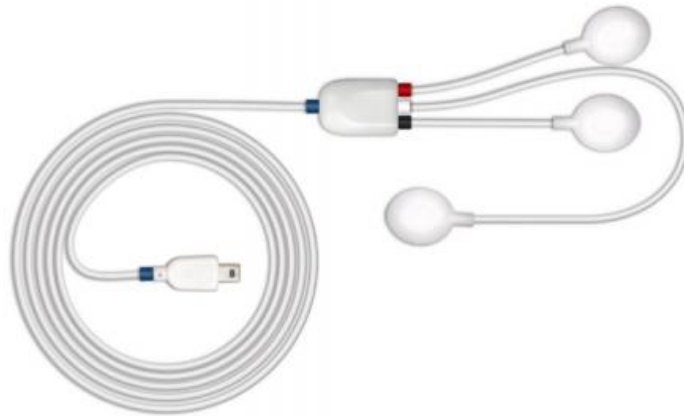
Figure 1: biosignalsplux Electroencephalography (EEG) sensor (standard version).

1.2. Typical Unfiltered Sensor Output

Figure 2 shows a typical unfiltered EEG sensor output acquired while at rest. The raw digital sensor values received from the biosignalsplux device ranged between 0 and 2^n-1 (n=sampling resolution) were converted into the original unit of measurement of this sensor (µV) using the transfer function found in section Transfer Function (Conversion Formula).
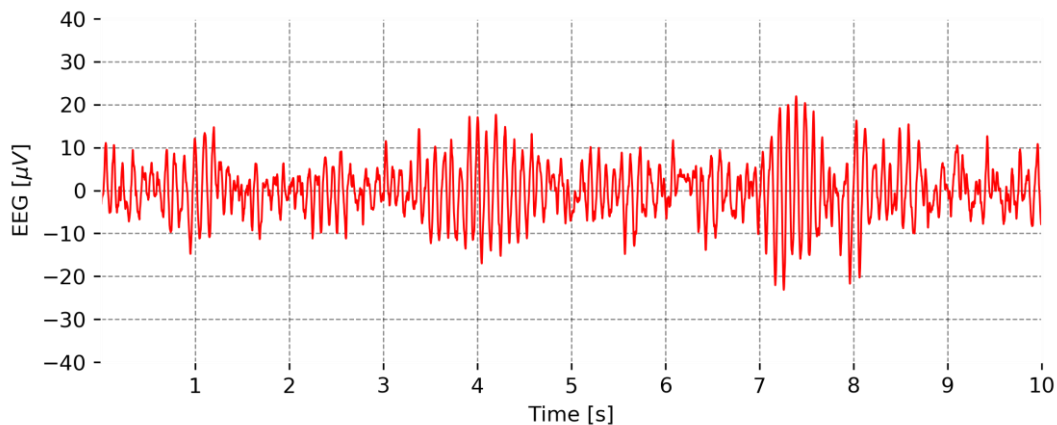
Figure 2: Typical unfiltered EEG sensor output (signal acquired while at rest).

1.3. Sensor Specifications

> Gain:	41780	**> Range:**	$\pm$ 37.5µV (@ VCC = 3V)
> Bandwidth:	0.8 – 48,23Hz	**> Consumption:**	~0.500mA
> Input Impedance:	> 100GOhm	**> CMRR:**	100dB

1.4. Features

> Single-channel differential sensor

> Pre-conditioned analog output

> High signal-to-noise ratio

> Medical-grade raw data output

> Unobtrusive & lightweight sensor

> Shielded miniaturized cables

> Ready-to-use form factor

> Discrete elastic head band

1.5. Applications

> Life sciences studies

> Neurofeedback

> Brain-Computer-Interfaces

> Biomedical device prototyping

> Psycho-Physiology

1.6. Transfer Function (Conversion Formula)

The analog sensor signals acquired with biosignalsplux devices are converted into digital values ranged between 0 and 2^n-1 (n=sampling resolution, usually 8-bit or 16-bit) and streamed in the raw digital format.

In most applications, the original physical unit of the acquired EEG signal is preferred or required. The raw digital sensor samples can be converted back into micro-Volt (µV) using the following formulas:

$$EEG(V) = \frac{\left(\frac{ADC}{2^n \text{ - }1} - \frac{1}{2}\right) * VCC}{G_{EEG}} \tag{1}$$

$$EEG(\mu V) = EEG(V).1 * 10^6 \tag{2}$$

Valid sensor range: [-37.5µV, 37.5µV]

with:
$EEG(V)$	EEG signal in Volt (V)
$EEG(\mu V)$	EEG signal in micro-Volt (µV)
ADC	Value samples from the sensor/channel (digital value)
n	Sampling resolution (default: 16-bit resolution (n=16), although 12-bit and 8-bit may also be found)
VCC	Operating voltage (3V when used with biosignalsplux)
G_{EEG}	Sensor gain (40000)

1.7. Electrode Connections & Sleeve Color Meanings

Sleeve Color	Red	Black	White
Electrode Cable	+	-	reference

See section *2 Application Notes* for more information on where to place the electrodes and to connect electrodes cables for EEG acquisitions.

1.8. Physical Characteristics

> W1 x L1 x H1:	1.0cm x 1.8cm x 0.4cm	**> W2 x L2 x H2:**	1.5cm x 2.3cm x 0.4cm
> A1:	105.0±0.5cm	**> A2:**	2.5±0.5cm
> A3:	10.0±0.5cm	**> D:**	0.4cm
> Available sleeve colors:	White, Black, Blue, Green, Red, Yellow, Gray, and Brown		

Sensor also available with A2 and A3 with 30cm cable lengths. Custom cable lengths for A1, A2, and A3 are possible. For custom lengths, please contact our operations team via orders@plux.info.
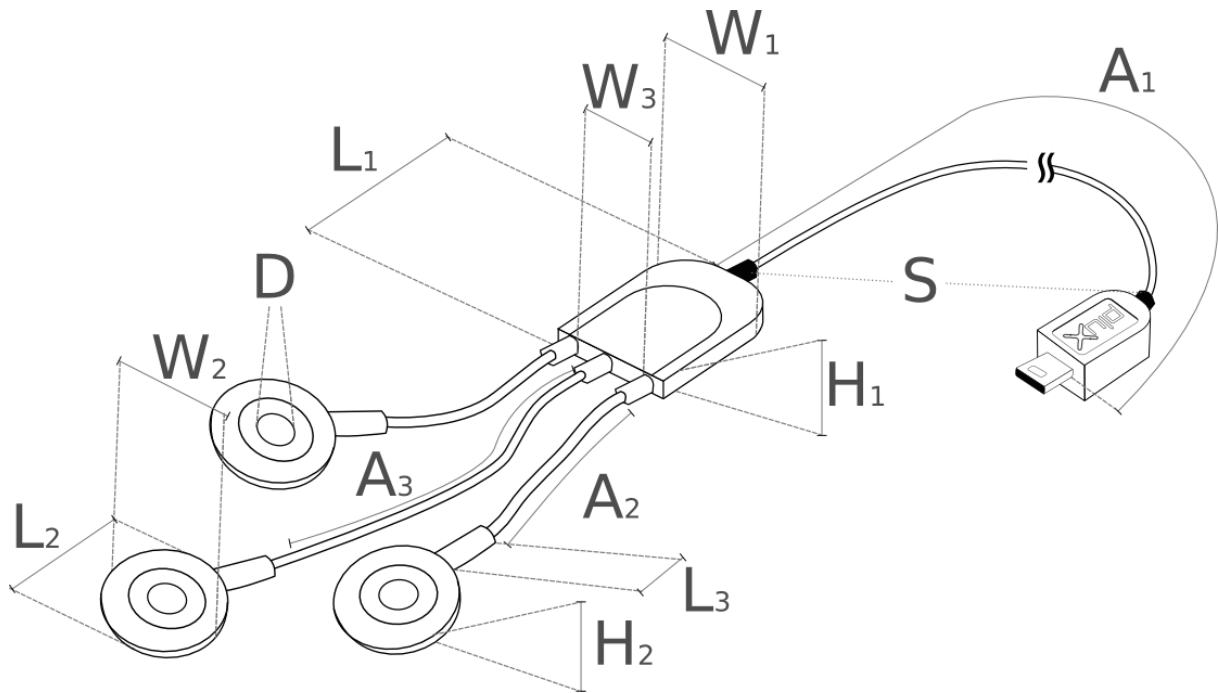

Figure 3: Physical characteristics of the standard Electroencephalography (EEG) sensor.

2. Application Notes & Electrode Placement

The biosignalsplux EEG is primarily designed for single-lead EEG acquisitions. For conventional EEG data acquisitions, electrodes are placed according to the 10-20 system to measure the electric potentials from the skin. The potential differences are measured between each electrode and a reference electrode whereas in bipolar recording such as the one existent on PLUX's sensors, the potential difference is measured between adjacent electrodes. Hence when using a single biosignalsplux EEG sensor with two electrodes, one needs to decide on one specific electrode position of the 10-20 system relating to the desired brain region for data acquisition.

Example:

- Electrode I: FP1 – forehead
- Electrode II: FP2 - forehead
- Electrode III: M1 – mastoid process (behind ear)

The illustrations shown in Figure 4 and Figure 5 illustrates the recommended electrode placement for the acquisition of neural activity in the prefrontal lobe.
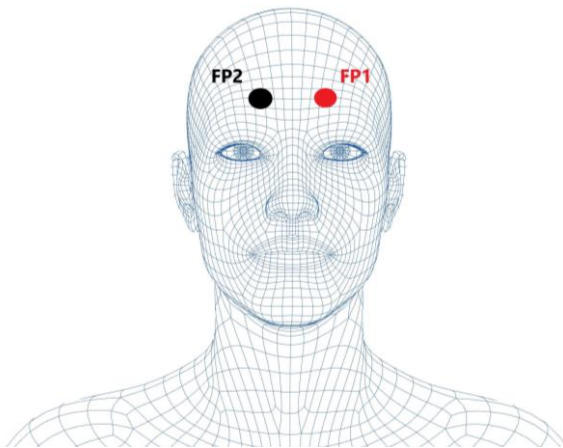
Figure 4: Electrode placement on the forehead
for EEG acquisition in 10-20 system configuration
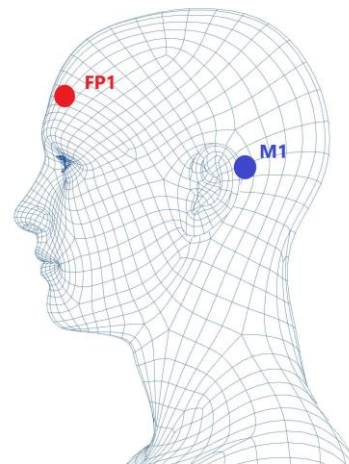
Figure5: Electrode placement of reference electrode
for EEG acquisition in 10-20 system configuration

After placing the EEG electrodes correctly on the skin, connect the electrode cables of the EEG sensor according to one of the following configurations:

Table 1: EEG sensor electrode and electrode placement connection.

	Positive Electrode (+) (red sleeve)	Negative Electrode (-) (black sleeve)	Reference Electrode (white sleeve)
I	FP1	FP2	M1
II	FP2	FP1	M1

3. Using the Electrocardiography (EEG) Sensor with biosignalsplux & OpenSignals

3.1. Connecting the sensor to biosignalsplux Systems

3.1.1. biosignalsplux 4-Channel Hubs

The biosignalsplux EEG sensor is compatible with all 8 analog input channels of the 4-channel biosignalsplux hub, but incompatible with the reference/ground port. Connect the sensor the analog input to use it with this device.

Figure 4: EEG compatible biosignalsplux channels (green checkmarks).

3.1.2. biosignalsplux 8-Channel Hubs

The biosignalsplux EEG sensor is compatible with all 8 analog input channels of the 8-channel biosignalsplux hub, but incompatible with the reference/ground and digital I/O ports. Connect the sensor to an analog input to use it with this device.
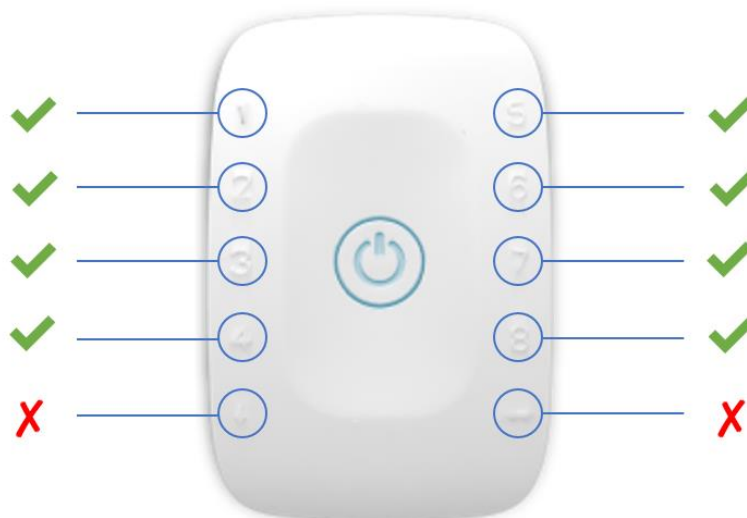
Figure 5: EEG compatible biosignalsplux channels (green checkmarks).

3.1.3. biosignalsplux Solo & Single-Channel openBAN Devices

The biosignalsplux EEG sensor is compatible with the analog input channel of the biosignalsplux Solo (openBAN) device. Connect the sensor to the analog input channel to use it with this device.

Figure 6: Connect the EEG to the analog input channel of the biosignalsplux Solo (openBAN).

3.2. Configuring the Sensor in OpenSignals

3.2.1. OpenSignals (r)evolution (Windows, macOS, Linux)

Open the OpenSignals (r)evolution device manager to access and configure your biosignalsplux device.

Figure 7: Access the OpenSignals (r)evolution device manager.

Select the device you intend to use for acquisition by clicking on *ENABLE button on* the device panel in the OpenSignals device manager. The device is activated for acquisition if the *ENABLE* button is blue.

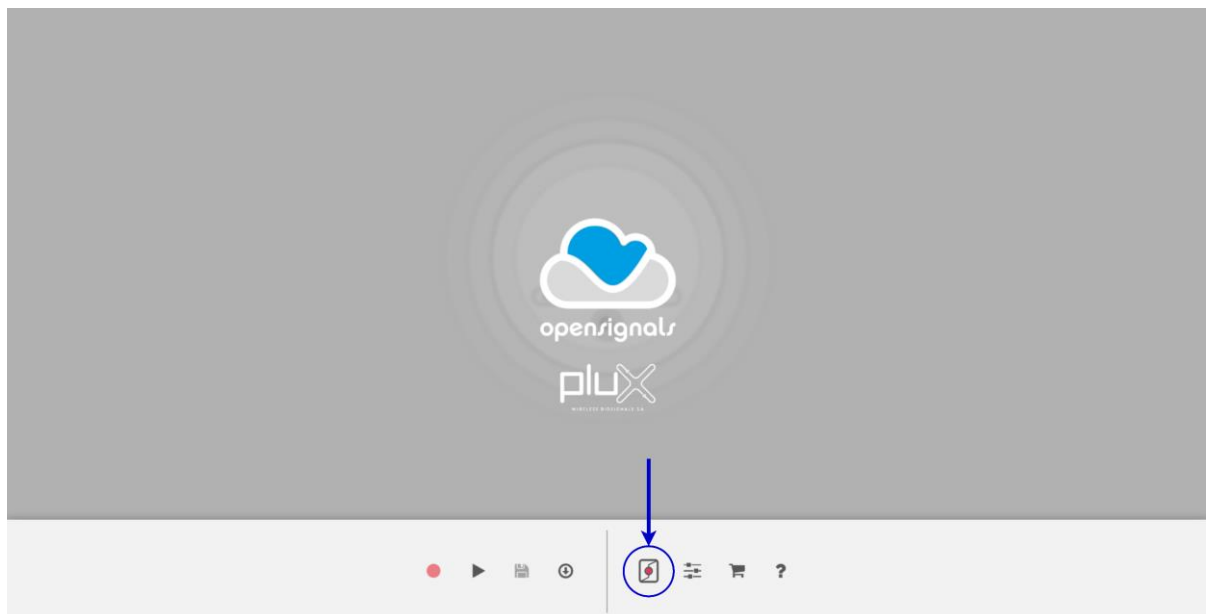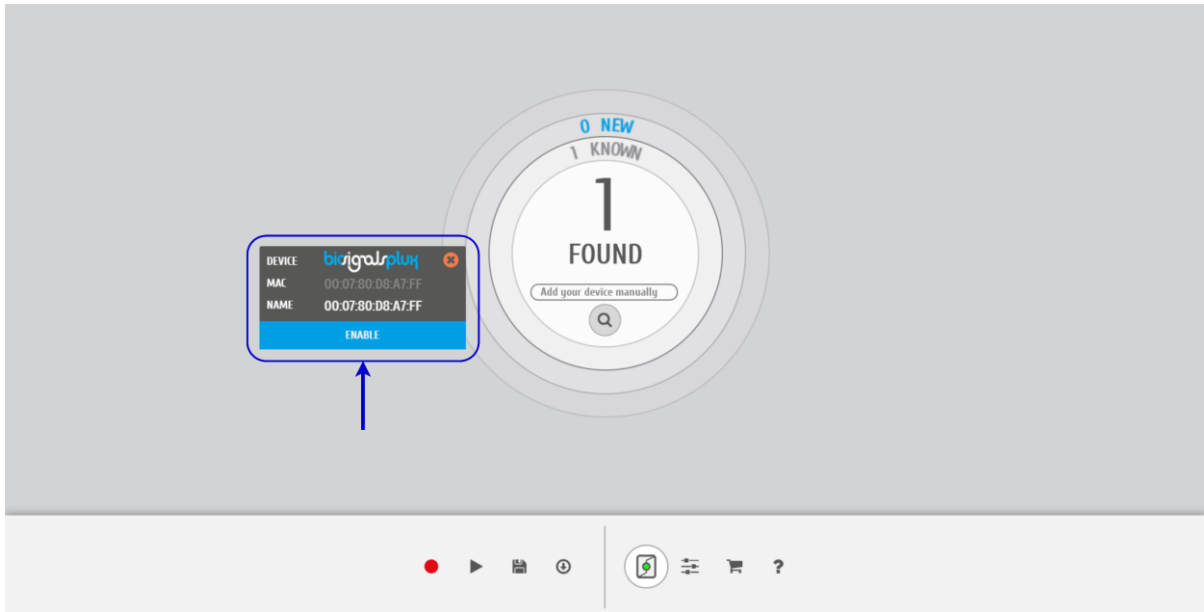Figure 8: Enabling the device for acquisition.

Click on the biosignalsplux logo to access the available settings. Select the channel your sensor is connected to and select the *EEG* from the dropdown menu highlighted in the next screenshot.
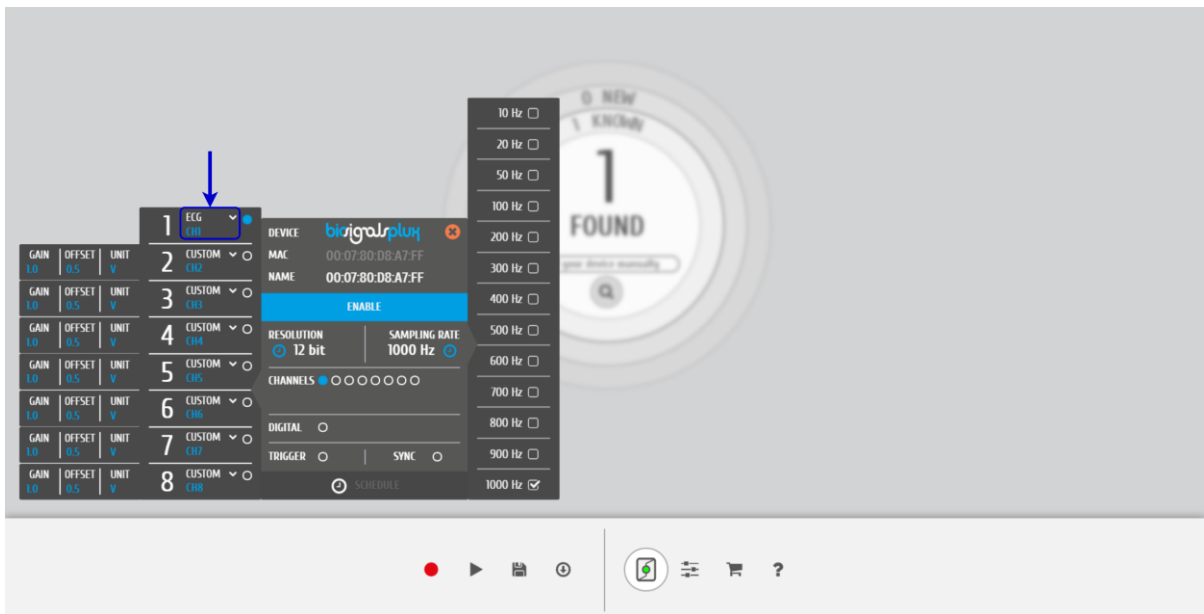
Figure 9: Set the channel type of the channel you have your EEG sensor connected to, to *EEG*.

Activate the channel for acquisition by clicking on the circle next to the channel type (must be blue). If not done before, follow the instruction available in section 2 *Application notes* to learn how to apply the sensors and *3.1 Connecting the sensor to biosignalsplux Systems* to learn how to connect your device to your biosignalsplux device. Click on the record button in the OpenSignals main interface whenever you're ready for your acquisition.
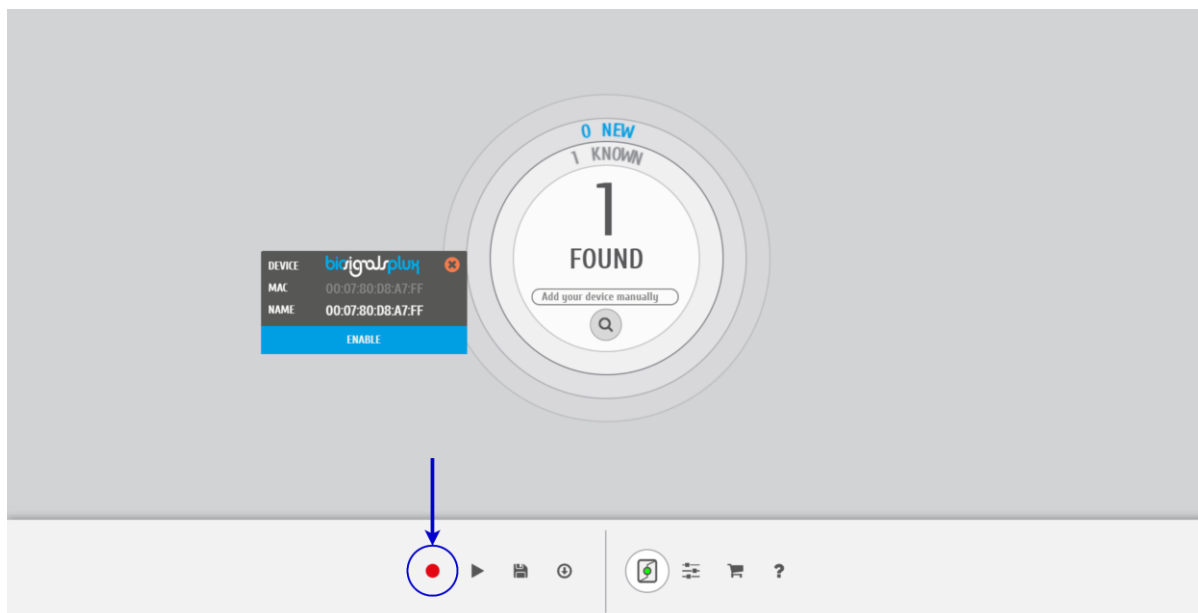
Figure 10: Start the acquisition whenever you're ready.

4. Scientific Publications Using the Electroencephalography (EEG) Sensor

The following scientific is only a small selection extracted from the list of available publications using biosignalsplux. Please visit the following website to access the entire up-to-date list:

🌐 **biosignalsplux Publications**
List of Publications

Publications

P. Morais, C. Quintão, "The mindfulness mediation effect on brain electrical activity: stress assessment, concentration state and quality of life", in Proceedings of the 12th International Conference on Bio-inspired Systems and Signal Processing, 2019

E. Costa, K. Baptista, J. Cavalho, J. Costa, "Influence of thermal environment on occipital EEG signal amplitude in sedentary activities", in International Journal of Occupational and Environmental Safety, 2019

J. Heinisch, I. Hübener and K. David, "The Impact of Physical Activities on the Physiological Response to Emotions", in Proc. of the 2nd Int. Workshop on emotion awareness for pervasive computing with mobile and wearable devices, pp. 824-829, 2018

A. Hariharan, M. T. P. Adam and K. Fuong, "Towards Understanding the Interplay of Cognitive Demand and Arousal in Auction Bidding", in Proc. of the 22nd European Conf. on Information Systems (ECIS), 2014

T. Araújo, N. Nunes, S. Palma and H. Gamboa, "Alpha rhythm onset detector based on localized EEG sensor", in Proc. of 7th ESBME-European Symposium on Biomedical Engineering, Chalkidiki, Greece, 2010

5. Safety & Maintenance

5.1. Safety Instructions

Please read the following safety instructions **before** using your *biosignalsplux* system with the EEG sensor to prevent any damages or problems with the user, test persons and/or *biosignalsplux* devices. Violations of these instructions can lead to inferior signal quality and/or damages to the *biosignalsplux* system and user.

! The user should always keep the device and its accessories dry.

! The user must turn off the *biosignalsplux* device and contact Technical Support if the system or accessories reach uncomfortable temperatures.

! The user should not use the *biosignalsplux* device in noisy environments (environments with microwaves and other similar equipment). Doing so will lead to noise increase in the acquired signals and Bluetooth connectivity issues.

! The user must not use the device near the fire or in potentially explosive atmospheres, such as atmospheres with flammable gas.

! The user should only use the detection surfaces or other approved accessories purchased from PLUX or by a PLUX agent.

! The user should inspect the sensors on a regular basis to ensure that they remain in good working order.

! The user should stop using the *biosignalsplux* device if experience any kind of discomfort or skin irritation.

! Do not use the system on persons with allergies to silver.

! The user should dispose detection surfaces after using the *biosignalsplux* device. Detection surfaces are single-user and disposable. Reusable electrodes should be reused by the same user. Do not use reusable electrodes on several users.

! The user must not place the device in the microwave.

! The user must not insert objects into the holes of the device.

! The user should not open the *biosignalsplux* device or its accessories. The repair of the same should be only done by properly authorized PLUX personnel.

! The user should make sure the cables do not obstruct the passage of people.

! The user should use the sensor cables with extreme caution to avoid risk of strangulation.

! The user should keep a safe distance between the *biosignalsplux* device and other devices to ensure their proper functioning.

! The user should only send the device to repair to qualified PLUX personnel.

! The user should not immerse the sensors or the *biosignalsplux* device, nor clean with liquid or abrasives.

! The user should handle the *biosignalsplux* device with caution and not expose the device or accessories to high accelerations and vibrations.

! *biosignalsplux* devices should not be used in patients with implanted electronic devices of any kind, including pace-makers, electronic infusion pumps, stimulators, defibrillators or similar.

! Do not apply electrodes over damaged or irritated skin.

! Do not use your device while charging its internal battery.

5.2. Transportation and Storage

Please follow these recommendations to ensure safe transportation and storage of your *biosignalsplux* equipment and sensors to prevent any damaging of your system.

The *biosignalsplux* equipment and sensors should be stored in the original box in a dry place when those are not being used.

- Relative humidity: up to 95% with no condensation
- Ambient temperature: 10°C to 30°C
- Atmospheric pressure between 500hPa and 1060hPa

Whenever the equipment needs to be transported, it should be placed in the original box, since this was designed and tested to ensure the equipment and accessories are securely stored.

Take care while handling the transportation of the system and avoid dropping it, since the device is not shock-proof and should not be placed under stress or sudden acceleration.

5.3. Cleaning

Please follow these cleaning instructions to prevent any damage of the system or the user because of conducting cleaning methods that may cause any damage.

- The *biosignalsplux* and sensors should be visually checked before each use and cleaning process to ensure that no mechanical damage occurred.

- The *biosignalsplux* equipment and sensors (including the cables) should be cleaned with a slightly damp cloth or suitable absorbent paper, ensuring no liquid enters the equipment of sensors. Do not use detergent or any type of cleaning liquid as these may damage your equipment and/or sensor.

- Do not clean or re-use detection surfaces (electrodes). They are only suitable for single use, and should be disposed of after usage except indicated otherwise.

6. Ordering Guides, Regulatory & Legal Information

6.1. Ordering Guide

Please follow the following ordering guide when submitting orders of EEG sensors to orders@plux.info. If no specification is provided, the standard version of the sensor will be delivered.

Electroencephalography (EEG) Sensor

SKU Reference	PLUX Code	UPC
SENSPRO-EEG	820 201 206	641945959710
Description		
Electroencephalography (EEG) sensor with standard physical characteristics and a random cable sleeve color		

Electrodes & Accessories

For a full list of available and compatible electrodes, please visit the biosignalsplux store.

6.2. Guarantee of Quality & Warranty

biosignalsplux sensors have three months quality guarantee from the date of purchase. PLUX guarantees that the system, sensors and accessories will be free from material or manufacturing defects for the mentioned time periods following date of purchase.

If PLUX receives notification of any such defects within the guarantee period, it will repair or substitute with the same unit\model, any products with proven defects at no cost to the client. During the repair period PLUX promises to provide a temporary replacement under the same specification. Repairs will be carried out at PLUX's premises after the equipment has been received.

6.3. Warranty Voidance

Usage of the device that is not in accordance with the handling instructions indicated in the manual, or use with accessories other than those manufactured by PLUX will invalidate the warranty of your devices.

Be careful when connecting your biosignalsplux devices, sensors and/or accessories to any third party device including the usage of the 3rd party connection components that are available for biosignalsplux systems as **the usage of these components will void the electrical warranty of your biosignalsplux device and sensors and, if not indicated otherwise, the warranty of the 3rd party system you're connecting to the device**. Check the electrical specifications of both systems you want to connect to prevent any damage of the user(s) or the systems.

In the case of warranty voidance, the same applies that we expressly disclaim any liability whatsoever for any direct, indirect, consequential, incidental or special damages, including, without limitation, lost revenues, lost profits, losses resulting from business interruption or loss of data, regardless of the form of action or legal theory under which the liability may be asserted, even if advised of the possibility of such damages.

6.4. Contact & Support

Contact us if you are experiencing any problems that cannot be solved with the information given in the biosignalsplux documentation.

Please send us an e-mail with precise information about the error occurrence, device configuration, and, if possible, screenshots of the problem to support@plux.info.

6.5. Regulatory Disclaimer

biosignalsplux products are intended for use in life science education and research applications; they are not medical devices nor are they intended for medical diagnosis, cure, mitigation, treatment or prevention of disease. We expressly disclaim any liability whatsoever for any direct, indirect, consequential, incidental or special damages, including, without limitation, lost revenues, lost profits, losses resulting from business interruption or loss of data, regardless of the form of action or legal theory under which the liability may be asserted, even if advised of the possibility of such damages.