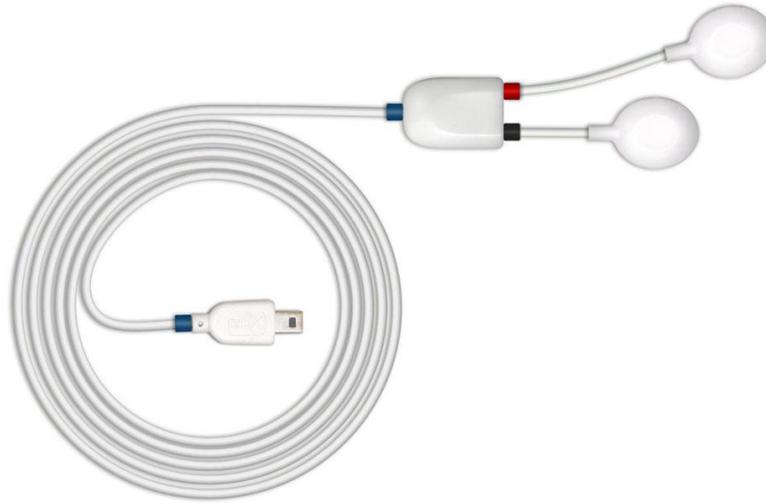




biosignal acquisition tool-kit for advanced research applications

Electromyography (EMG) Sensor User Manual



ATTENTION

Please read this datasheet before
using your biosignalsplux sensor

The information contained in this document has been carefully checked and we 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.

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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.

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1. General Information

1.1. General Description

The biosignalsplux Electromyography (EMG) is designed to monitor muscular activity even in the most extreme conditions. The bipolar configuration is ideal for uncompromised low-noise data acquisition, and the raw data output provides medical-grade data enabling it to be used for advanced and highly accurate biomedical, biomechanics, and sports research, among many other possible applications.

Together with our available [EMG Analysis](#) and [Muscle Load Analysis](#) add-ons for our [OpenSignals \(r\)evolution](#) software, one can easily extract statistical temporal and spectral parameters for further analysis of the acquired sensor data.

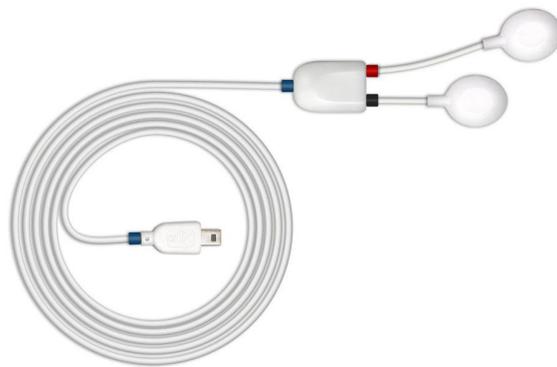


Figure 1: biosignalsplux Electromyography (EMG) sensor (standard version).

1.2. Typical Unfiltered Sensor Output

Figure 2 shows a typical unfiltered EMG sensor output acquired along the muscle of the biceps while two muscular contractions are performed over a time of 10 seconds. 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 (mV) using the transfer function found in section Transfer Function (Conversion Formula).

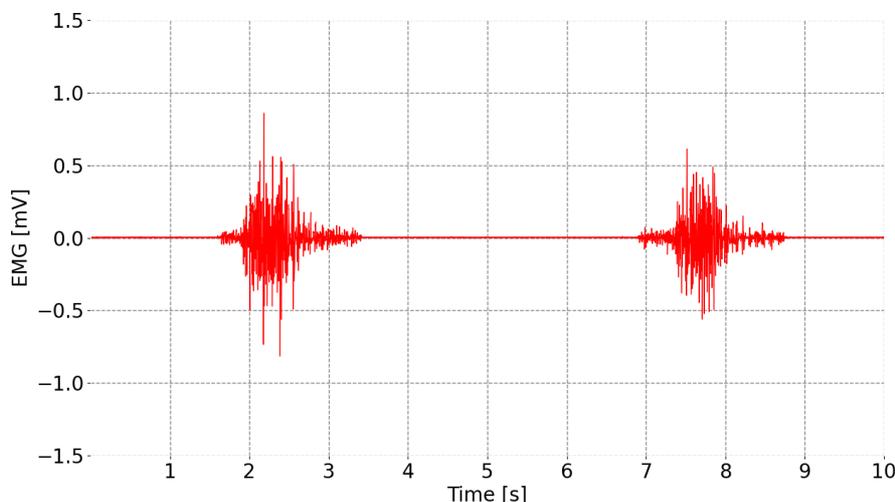


Figure 2: Typical unfiltered sensor output (signal acquired from the biceps while two contractions are performed).

1.3. Sensor Specifications

> Gain:	1007	> Range:	$\pm 1.49\text{mV}$ (@ $VCC = 3\text{V}$)
> Bandwidth:	25-500Hz	> Consumption:	$\sim 1\text{mA}$
> Input Impedance:	$> 100\text{G}\Omega$	> CMRR:	100dB

1.4. Features

- > Bipolar differential measurement
- > High signal-to-noise ratio
- > Medical-grade raw data output
- > Unobtrusive & lightweight sensor
- > Pre-conditioned analog output
- > Ready-to-use form factor

1.5. Applications

- > Life sciences studies
- > Biomedical Research
- > Human-Computer Interaction
- > Robotics & Cybernetics
- > Physiology studies
- > Biomedical device prototyping
- > Psychophysiology
- > Biomechanics
- > Ergonomics

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 EMG signal is preferred or required. The raw digital sensor samples can be converted back into millivolt (mV) using the following formulas:

$$EMG(V) = \frac{\left(\frac{ADC}{2^n} - \frac{1}{2}\right) \times VCC}{G_{EMG}} \quad (1)$$

$$EMG(mV) = EMG(V) \times 1000 \quad (2)$$

Valid sensor range: [-1.49mV, 1.49mV]

with: $EMG(V)$	EMG signal in Volt (V)
$EMG(mV)$	EMG signal in milli-Volt (mV)
ADC	Value samples from the sensor/channel (raw digital value)
n	Sampling resolution (default: 16-bit resolution ($n=16$), although 12-bit and 8-bit may also be found in older versions)
VCC	Operating voltage (3V when used with biosignalsplux)
G_{EMG}	Sensor gain (1007)

1.7. Electrode Connections & Sleeve Color Meanings

Sleeve Color	Red	Black
Electrode Cable	+	-

See Section 2 for more information on where to place the electrodes and to connect electrodes cables for EMG acquisitions.

1.8. Physical Characteristics

> W1 x L1 x H1:	1.6x2.2x0.5cm	> W2 x L2 x H2:	1.5x1.75x0.55cm
> W3:	0.9cm	> L3:	0.5cm
> A1:	105.0±0.5cm	> A2:	5.0±0.5cm
> A3:	2.5±0.5cm	> D:	0.4cm
> Available sleeve colors:	White, Black, Blue, Green, Red, Yellow, Gray, and Brown		

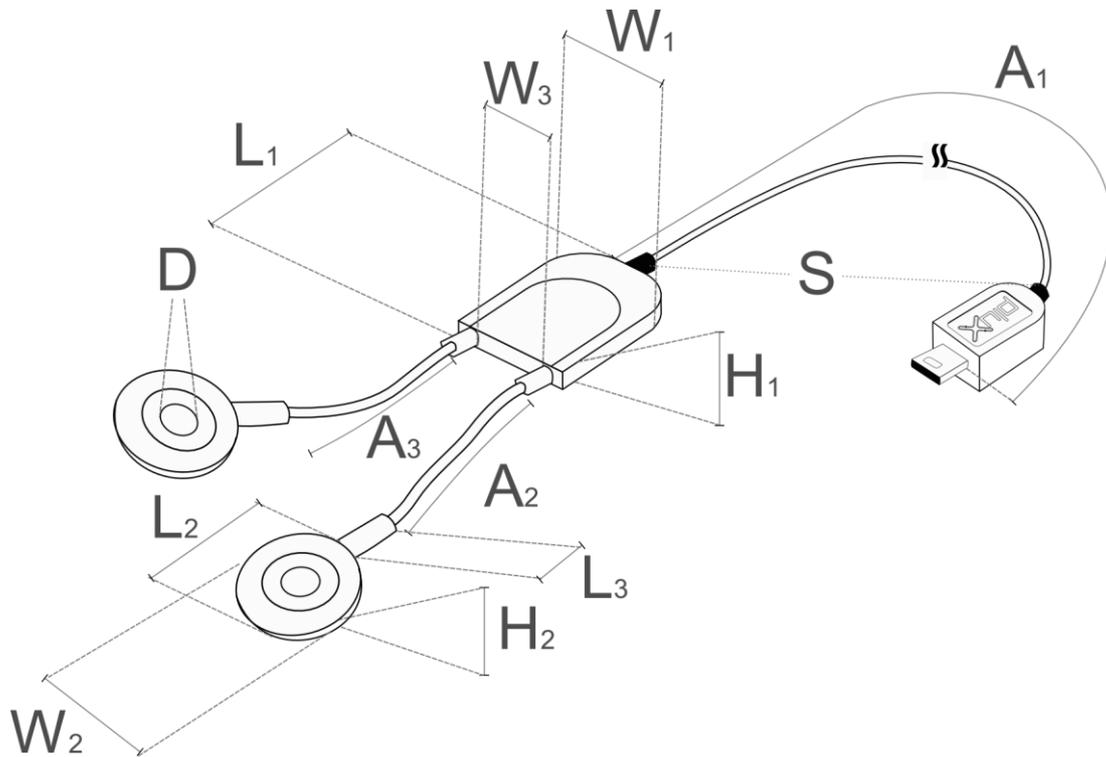


Figure 3: Physical characteristics of the standard Electromyography (EMG) sensor.

2. Sensor Application Notes

The **biosignalsplux** EMG is designed to acquire muscular activity along a muscle fibre of interest. Muscle activations are triggered by bioelectrical signals of very low amplitude sent from motor control neurons on our brain to the muscle fibres. Electromyography (EMG) enables the translation of these electrical signals into numerical values, enabling them to be used in a wide array of applications.

The two measuring electrodes must be placed along the muscle fibre and on the muscle belly. The reference electrode must be placed in a region of low muscular activity, optimally on a bone such as the elbow or the clavicle.

An example is the measurement of the muscular activity of the muscle **biceps brachii** (see muscle highlighted in red in Figure 4). The electrode positioning for this muscle is shown in Figure 4 in which the two measuring electrodes are placed on the muscle and the reference electrode on the bone.

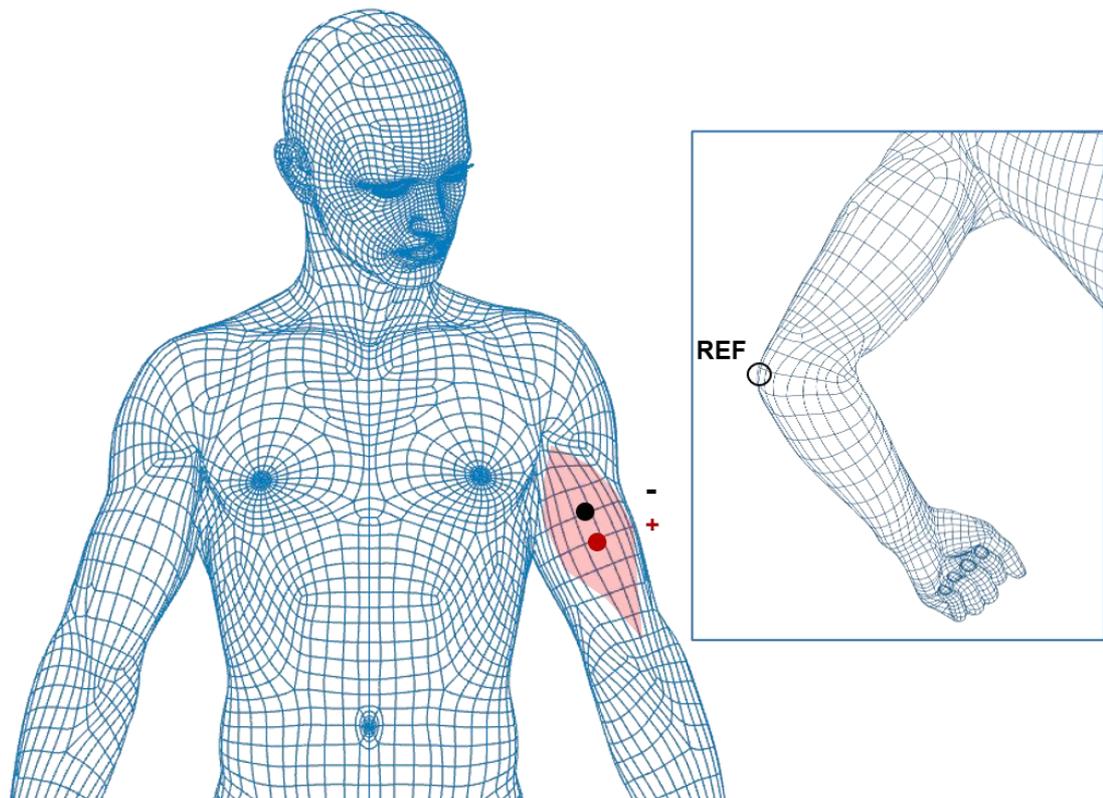


Figure 4: Electrode positioning (I) to measure signals from the muscle biceps brachii (marked in red).

Possible electrode positions are listed in Table 1. The positive and the negative measuring electrodes can be positioned in either way but along the muscle fibre and on the muscle belly. The reference electrode must always be positioned on a bone.

Table 1: Possible electrode positions.

	Positive Electrode (+) (red sleeve)	Negative Electrode (-) (black sleeve)	Reference Electrode (white sleeve)
I	Muscle position 1	Muscle position 2	Bone
II	Muscle position 2	Muscle position 1	Bone

The muscular contraction of the biceps brachii can be performed by flexion of the elbow and supination of the forearm (see Figure 5).

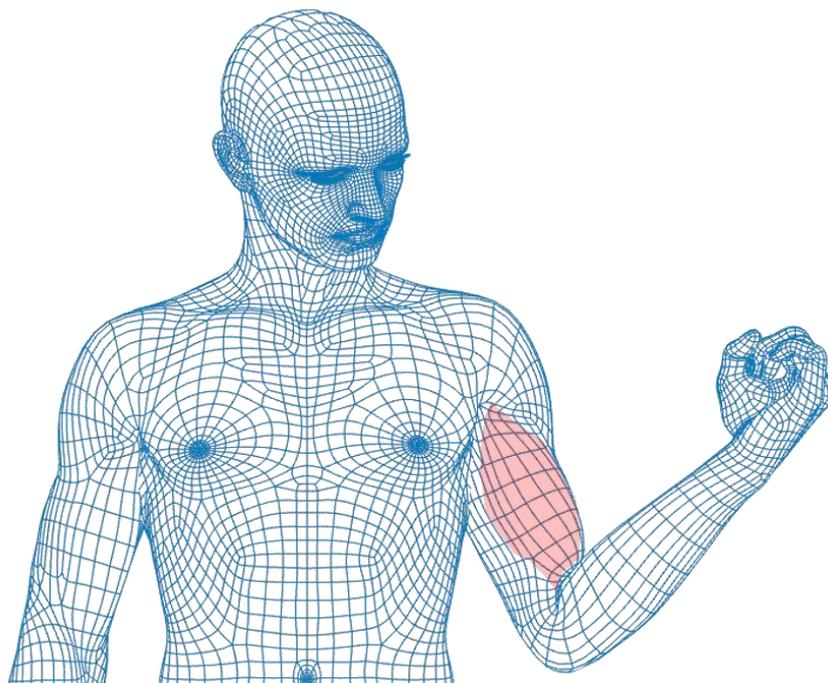


Figure 5: Muscular contraction of the muscle biceps brachii (marked in red) while performing flexion of the elbow, forearm in supination.

3. Using the Electromyography (EMG) Sensor with biosignalsplux & OpenSignals

3.1. Connecting the sensor to biosignalsplux Systems

3.1.1. biosignalsplux 4-Channel Hubs

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



Figure 6: EMG compatible biosignalsplux channels (green checkmarks).

3.1.2. biosignalsplux 8-Channel Hubs

The biosignalsplux EMG 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.

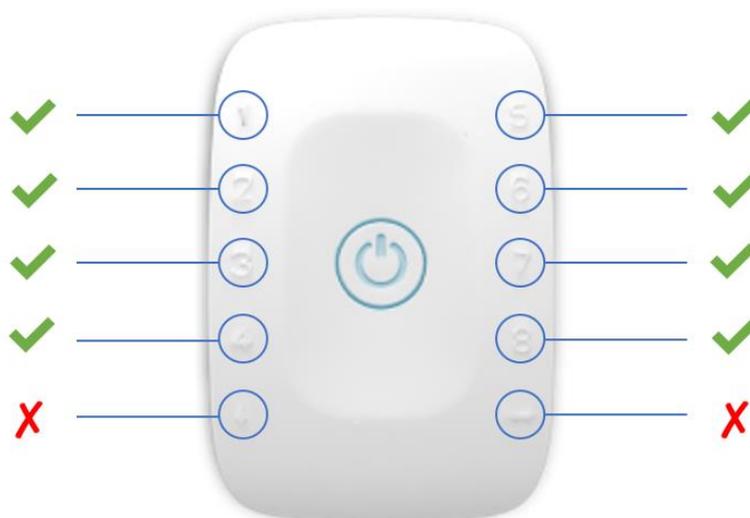


Figure 7: EMG compatible biosignalsplux channels (green checkmarks).

3.1.3. biosignalsplux Solo & Single-Channel openBAN Devices

The biosignalsplux EMG 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 8: Connect the EMG 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 9: 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.

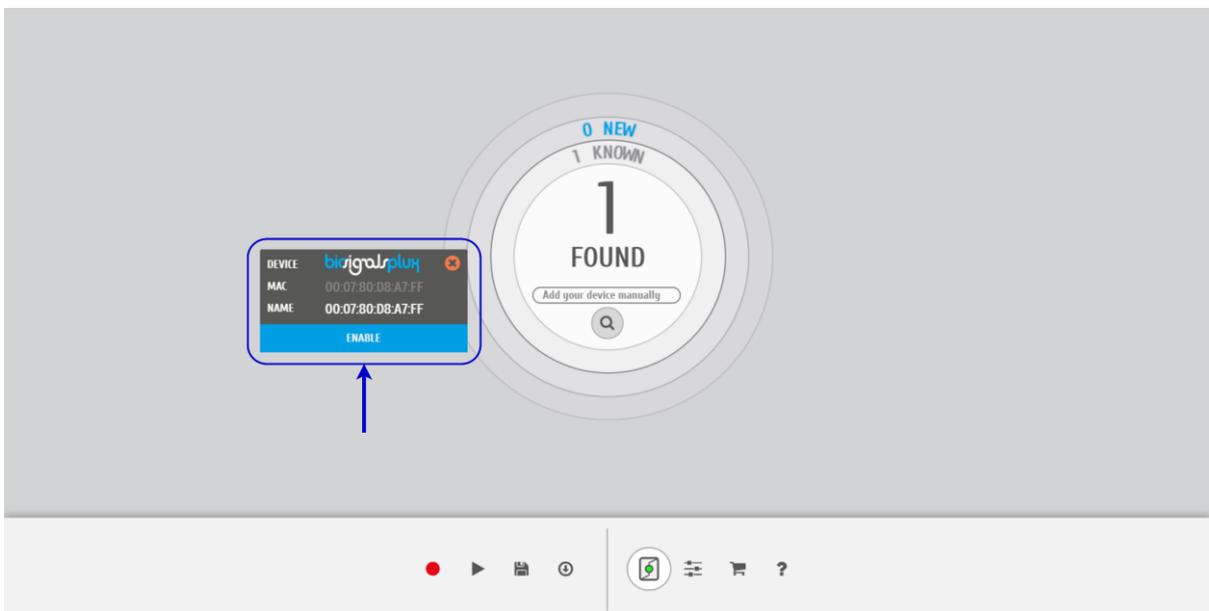


Figure 10: Enabling the device for acquisition.

Click on the biosignalsplux logo to access the available settings. Select the channel your sensor is connected to and select the *EMG* from the dropdown menu highlighted in the next screenshot.

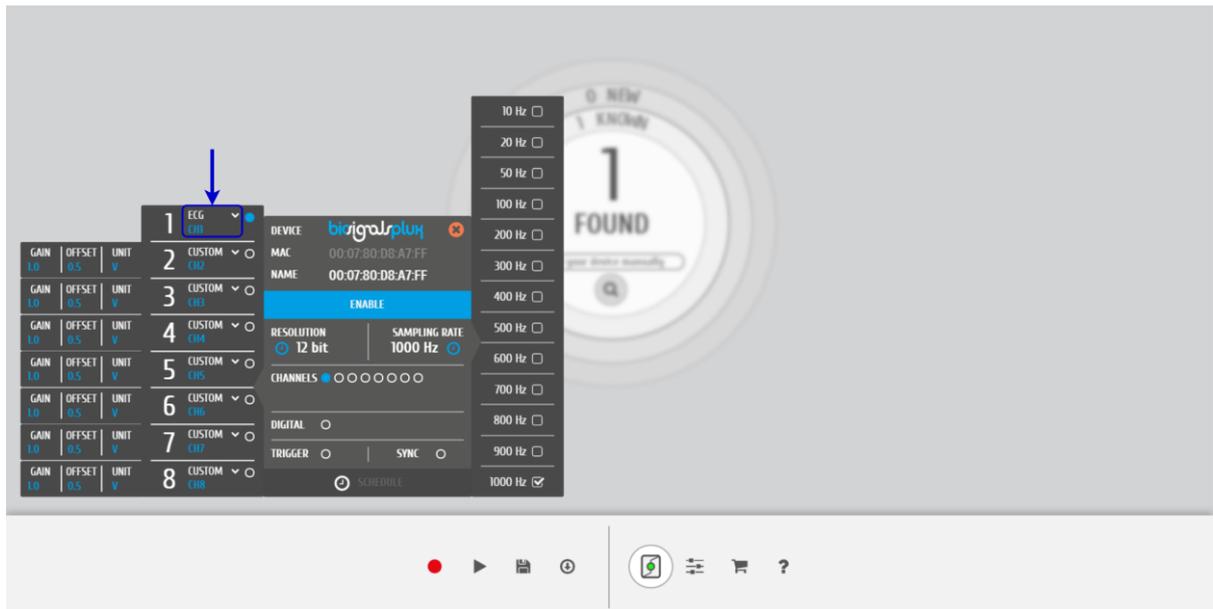


Figure 11: Set the channel type of the channel you have your EMG sensor connected to, to EMG.

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.

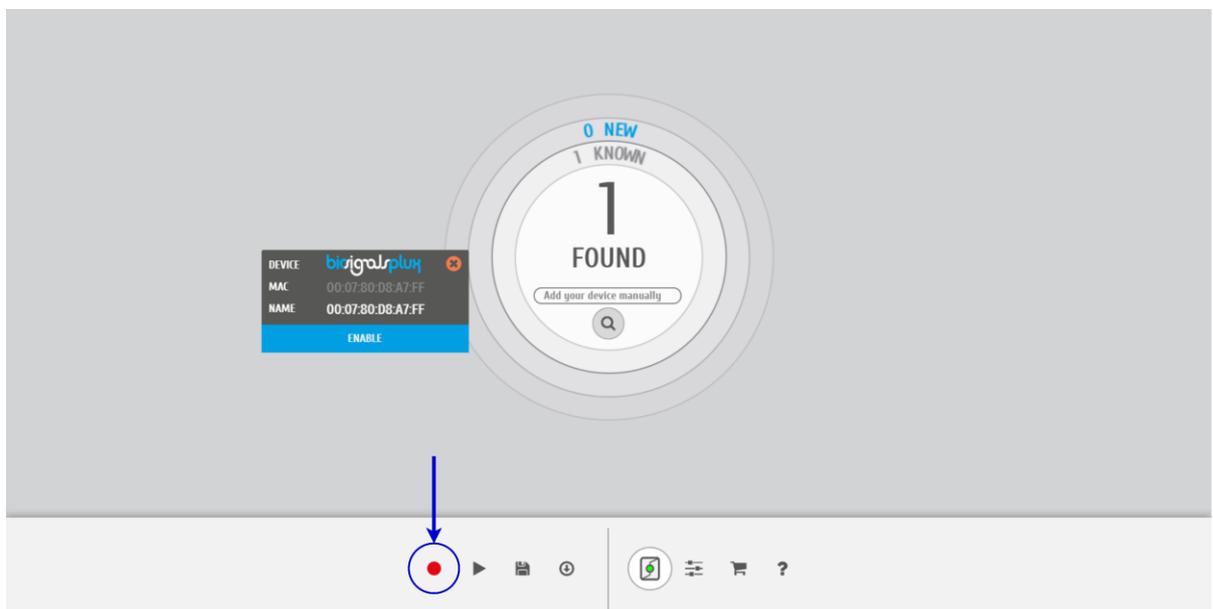


Figure 12: Start the acquisition whenever you're ready.

4. Technical Notes

The biosignalsplux technical notes aim to provide technical in-depth information about the different applications in which the EMG sensor can be applied. Find below a list of the available technical notes and the links to the respective documents.

[EMG Sensor Facial](#) – a technical note on how to apply the EMG sensor on facial muscles such as the buccinator muscle.

5. Scientific Publications Using the Electromyography (EMG) 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:

<https://biosignalsplux.com/learn/publications.html>

Publications

D. Silva, R. Macedo, A. Montes, R. Santos, J. Vilas-Boas, A. Sousa, "Does the cleat model interfere with ankle sprain risk factors in artificial grass?", in *Clinical Biomechanics*, vol. 63, pp. 119-126, 2019

A. Conceição, A. Silva, T. Barbosa, J. Campaniço, A. Costa, H. Louro, "Neuromuscular and motor patterns in breaststroke technique", in *Revista Brasileira de Cineantropometria & Desempenho Humano*, 2019

L. Costa e Silva, A. Silva, J. Teles, I. Fragoso, "Influence of physical activity intensity and maturation in injury profile on youth", in *Annals of Medicine*, 2019

A. Conceição, V. Milheiro, P. Sobreiro, M. Espada, H. Louro, "Muscle Activity Relationship Between Bicycle Geometric Parameters", in *STRONG*, vol. 15, pp. 130, 2019

I. Dias, L. Godinho, M. Pinho, G. de Sá, J. Sousa, Â. Pereira, "Participation of the agonist and antagonist knee extensor muscles in drop kick, placing kick and up and under kick, in rugby athletes", in *Annals of Medicine*, vol. 51, no. 1, pp. 2017, 2019

I. Valente, "Stiffness, coativação do antagonista e estabilidade postural em apoio uniodálico em indivíduos com instabilidade crónica do tornozelo", Master Thesis, 2018

A. Pereira, D. Folgado, R. Cotrim, I. Sousa, "Physiotherapy Exercises Evaluation using a Combined Approach based on sEMG and Wearable Inertial Sensors", in *Proceedings of the 12th International Conference on Bio-inspired Systems and Signal Processing*, 2019

J. Yepes, M. Portela, A. Saldarriaga, V. Pérez, M. Betancur, "Myoelectric control algorithm for robot-assisted therapy: a hardware-in-the-loop simulation study", in *BioMedical Engineering OnLine*, vol. 18, no. 3, pp. 1-28, 2019

D. Batista, H. Silva, A. Fred, C. Moreira, M. Reis, H. Ferreira, "Benchmarking of the BITalino biomedical toolkit against an established gold standard", in *Healthcare Technology Letters*, vol. 6, no. 2, pp. 32-36, 2019

O. Ribeiro, "Identificação de variáveis biomecânicas para a caracterização do tónus em indivíduos após acidente vascular cerebral: tónus muscular vs. Postural", Master Thesis, 2018

6. Safety & Maintenance

6.1. Safety Instructions

Please read the following safety instructions **before** using your *biosignalsplux* system with the EMG 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.

6.2. 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.

6.3. 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.

7. Ordering Guides, Regulatory & Legal Information

7.1. Ordering Guide

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

Electromyography (EMG) Sensor

SKU Reference	PLUX Code	UPC
SENPRO-EMG1	820201201	641945696264
Description		
Muscle activity measurement		

Electrodes & Accessories

For a full list of available and compatible electrodes, please visit the [biosignalsplux store](#).

7.2. 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.

7.3. 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.

7.4. 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.

7.5. 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.

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