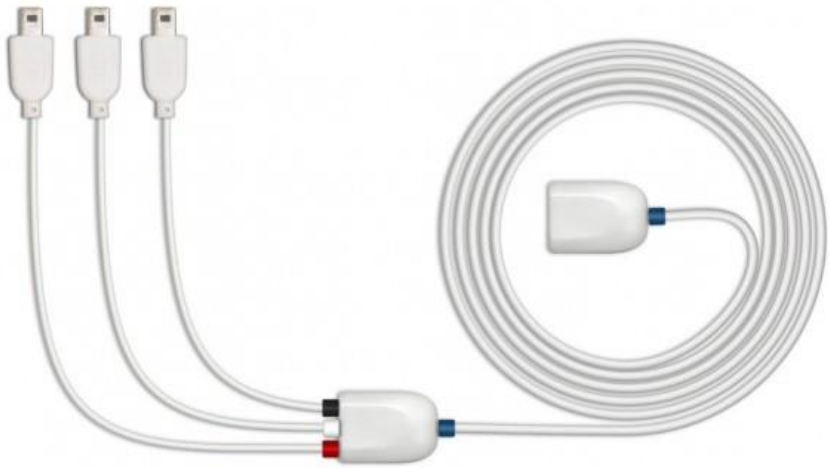
biosignal acquisition tool-kit for advanced research applications

Accelerometer (ACC) Sensor User Manual



ATTENTION
Please read this datasheet before
using your biosignalsplux sensor

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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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TABLE OF CONTENTS

1. General Information **4**
1.1. General Description **4**
1.2. Typical Unfiltered Sensor Output **4**
1.3. Sensor Specifications **5**
1.4. Features **5**
1.5. Applications **5**
1.6. Transfer Function (Conversion Formula) **5**
1.7. Physical Characteristics **6**
2. Application Notes **7**
3. Using the Accelerometer (ACC) Sensor with biosignalsplux & OpenSignals **8**
3.1. Connecting the sensor to biosignalsplux Systems **8**
3.1.1. biosignalsplux 4-Channel Hubs 8
3.1.2. biosignalsplux 8-Channel Hubs 8
3.2. Configuring the Sensor in OpenSignals **9**
3.2.1. OpenSignals (r)evolution (Windows, macOS, Linux) 9
4. Scientific Publications Using the SENS Sensor **11**
5. Safety & Maintenance **12**
5.1. Safety Instructions **12**
5.2. Transportation and Storage **13**
5.3. Cleaning **13**
6. Ordering Guides, Regulatory & Legal Information **14**
6.1. Ordering Guide **14**
6.2. Guarantee of Quality & Warranty **14**
6.3. Warranty Voidance **14**
6.4. Contact & Support **14**
6.5. Regulatory Disclaimer **14**
6.6. Document Version Tracking ..... Error! Bookmark not defined.

1. General Information

1.1. General Description

The **biosignalsplux tri-axial Accelerometer** (**ACC**) uses Micro-Electro-Mechanical Systems (MEMS®) technology for the acquisition of high-quality accelerometery data. This sensor can measure **sub-milliG** accelerations and provides raw data of each axis on individual channels, giving you full control about the acquired data.

ACC sensors are commonly found in motion tracking applications where this sensor can be used for the development of to measure physical activity, range of motion, as well as to conduct vibration analysis, which, for example, can be used to prevent ergonomic injuries or evaluate tremors of Parkinson patients.

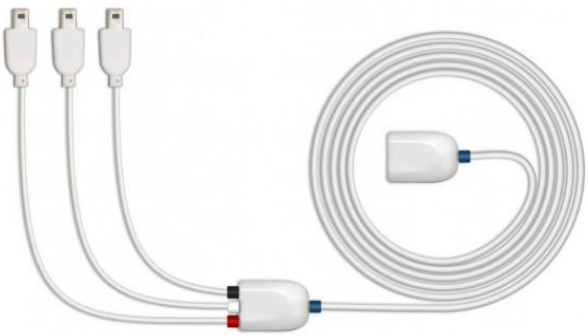

Figure 1: biosignalsplux ACC sensor (standard version)

1.2. Typical Unfiltered Sensor Output

Figure 2 shows a typical unfiltered **Accelerometer** sensor output acquired while doing an *8 like* movement in order to stimulate all axis. The raw digital sensor values received from the **biosignalsplux** device ranged between 0 and 2^n-1 (**n=sampling resolution**) can be converted into the original unit of measurement of this sensor (g) using the transfer function found in section **Transfer Function (Conversion Formula)**.

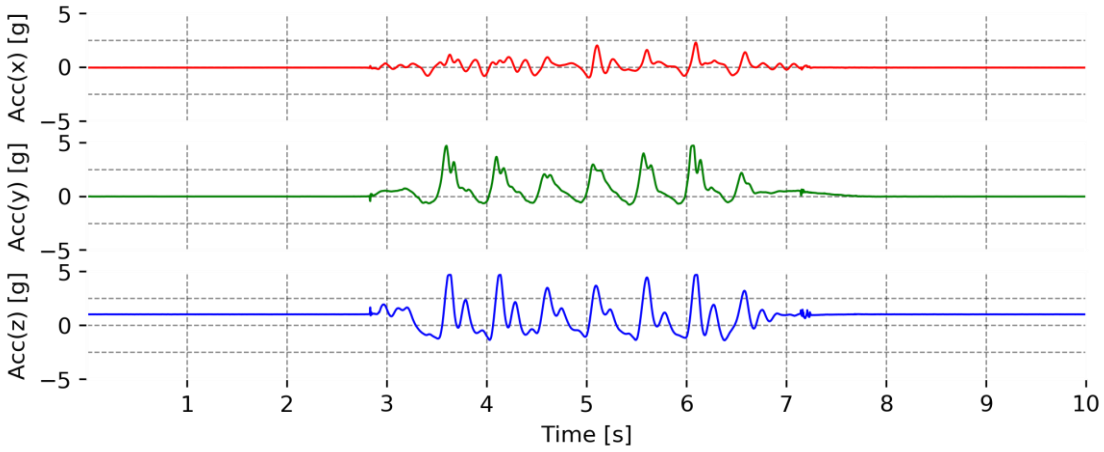

Figure 2: Typical unfiltered sensor output (doing an *8 like* movement in order to stimulate all axis).

1.3. Sensor Specifications

> Axis:	3	**> Range:**	±3.60 g
> Bandwidth:	0-50 Hz	**> Consumption:**	~0.35 mA

1.4. Features

> Tri-axial sensing
> MEMS technology
> High signal-to-noise ratio
> Medical-grade raw data output
> Unobtrusive & lightweight sensor
> Pre-conditioned analog output
> Ready-to-use and miniaturized form factor
> Raw data output

1.5. Applications

> Life sciences studies
> Activity monitoring
> Vibration measurement
> Robotics & Cybernetics
> Biomedical device prototyping
> Tilt detection
> Human-Computer interaction
> Biomechanics

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 **ACC** signal is preferred or required. The raw digital sensor samples can be converted back into relative gravitational acceleration/g-force (g) using the following formula:

$$ACC(g) = \frac{ADC - C_{min}}{C_{max} - C_{min}} \times 2 - 1 \quad (1)$$

Valid sensor range: [-3.60 g, 3.60 g]

with:

$ACC(g)$	ACC value in g-force (g)
ADC	Value samples from the sensor/channel (digital value)
C_{min}	Minimum calibration value[1]
C_{max}	Maximum calibration value

[1] For more information about C_{min} and C_{max}, please, check the content of section **2. Application Notes**.

1.7. Physical Characteristics

> W1 x L1 x H1:	1.6cm x 2.2cm x 0.5cm	**> W2:**	1.0±0.1cm
> W3:	1.0±0.1cm	**> W4:**	0.5±0.1cm
> L2:	1.3±0.1cm	**> L3:**	0.7±0.1cm
> A1:	105.0±0.5cm	**> A2:**	8.5±0.5cm
> H2:	0.7±0.1cm	**> S:**	0.3±0.1cm
>Available sleeve colors:	White, Black, Blue, Green, Red, Yellow, Grey, and Brown		

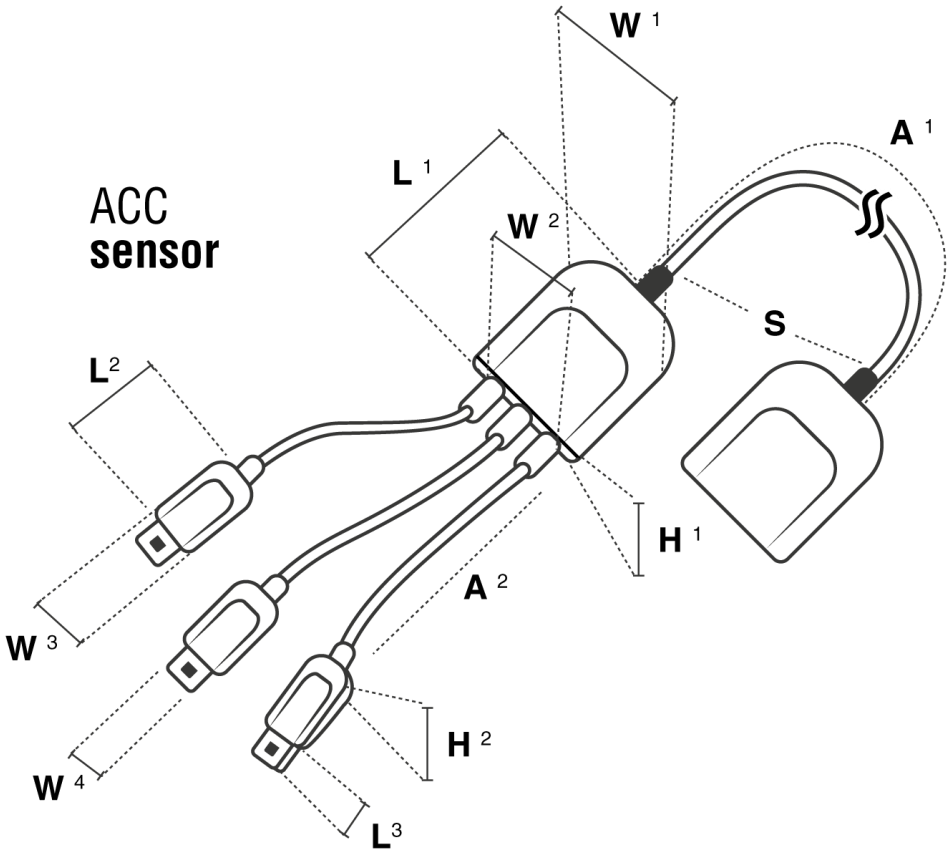

Figure 3: Physical characteristics of the standard ACC sensor.

2. Application Notes

This sensor requires a calibration to provide reliable measurements. The resulting calibration values (C_{min}& C_{max}) which are needed for the transfer function below are determined by performing a very slow 360° rotation of the sensor around each axis to force the accelerometer to cross the gravity-imposed −1g and 1g.

C_{min}& C_{max} define the minimum and maximum RAW data values, respectively, registered in the axis under analysis during the calibration protocol.

Axes/Channel Configuration

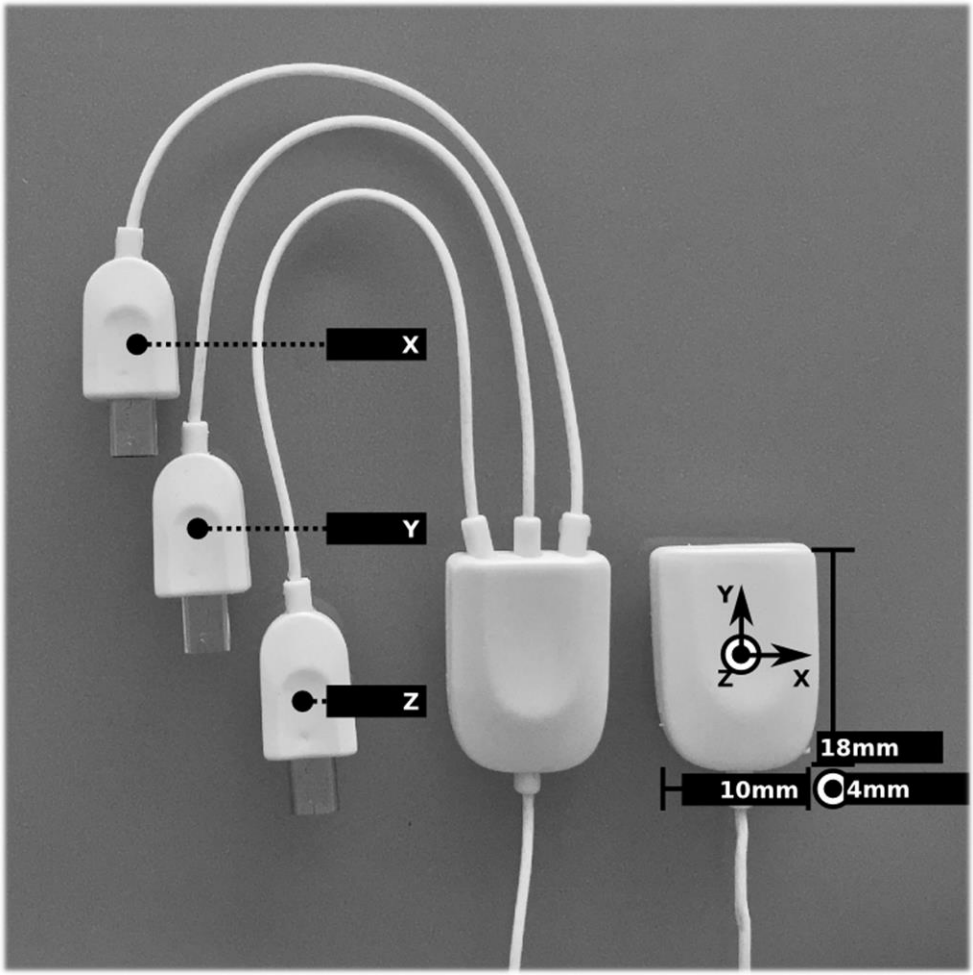

Figure 4: Relationship between each input cable and the respective axis under monitorization.

3. Using the Accelerometer (ACC) Sensor with biosignalsplux & OpenSignals

3.1. Connecting the sensor to biosignalsplux Systems

3.1.1. biosignalsplux 4-Channel Hubs

The **biosignalsplux ACC 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.

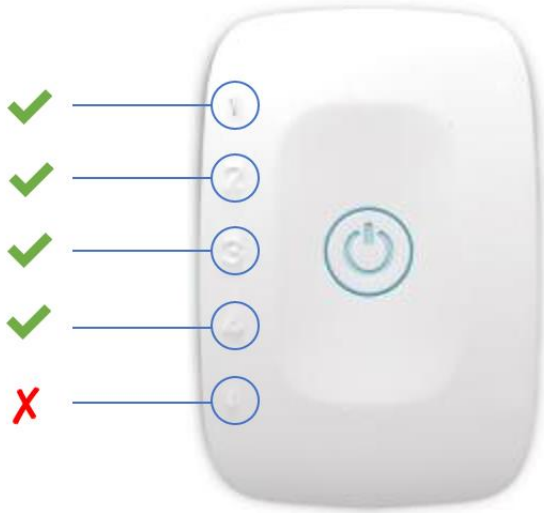

Figure 5: ACC compatible biosignalsplux channels (green checkmarks).

3.1.2. biosignalsplux 8-Channel Hubs

The **biosignalsplux ACC 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.

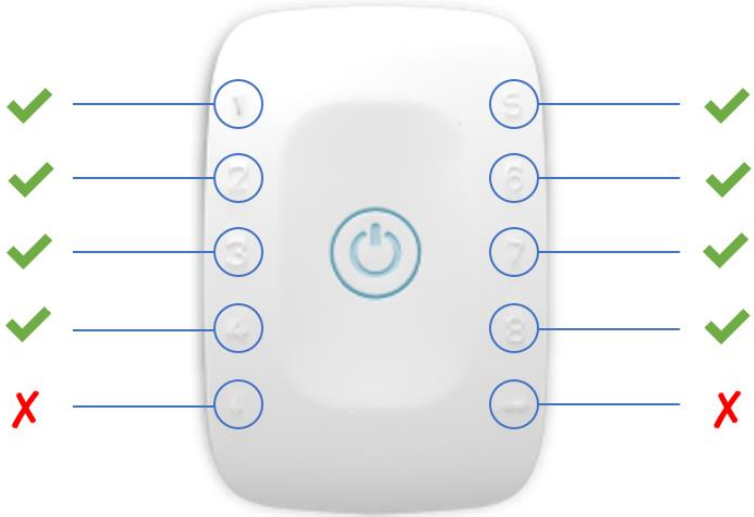

Figure 6: ACC compatible biosignalsplux channels (green checkmarks).

3.2. Configuring the Sensor in OpenSignals

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

Note
Download OpenSignals (r)evolution here: https://biosignalsplux.com/index.php/software

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

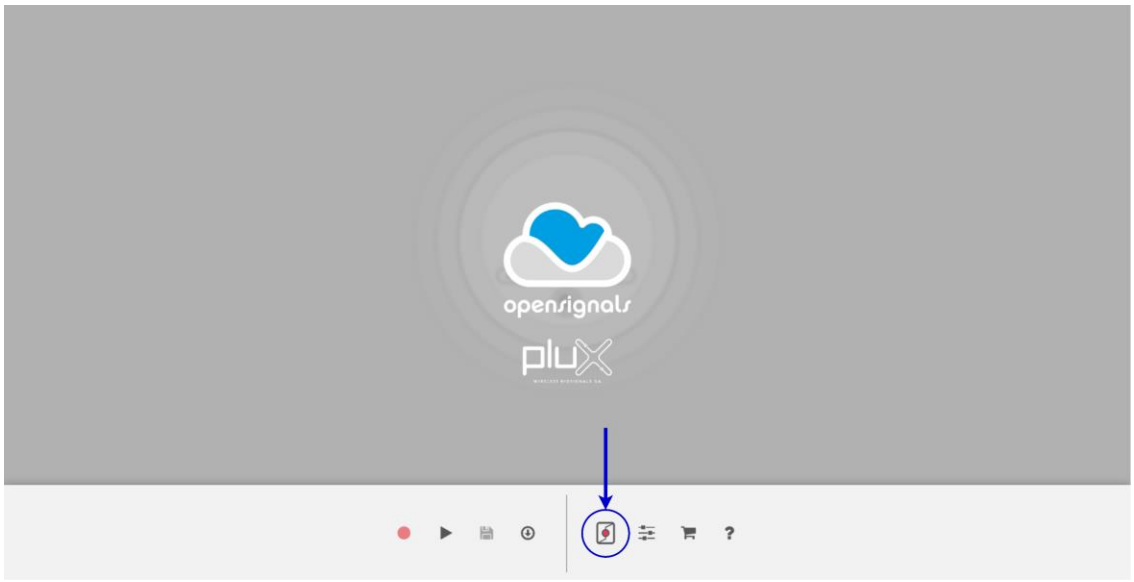

Figure 7: Access the OpenSignals (r)evolution device manager.

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 channels your sensor is connected to and select the *XYZ* from the dropdown menu highlighted in the next screenshot.

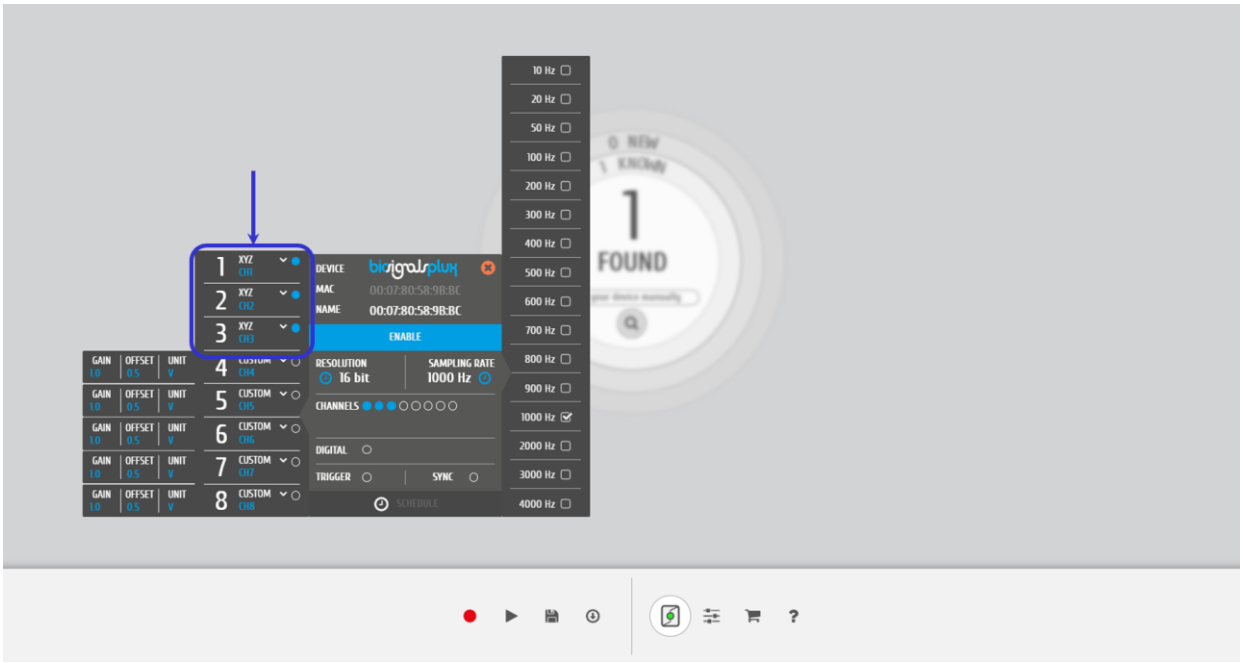

Figure 9: Set the channel type of the channels you have your ACC sensor connected to, to *XYZ*.

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 *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.

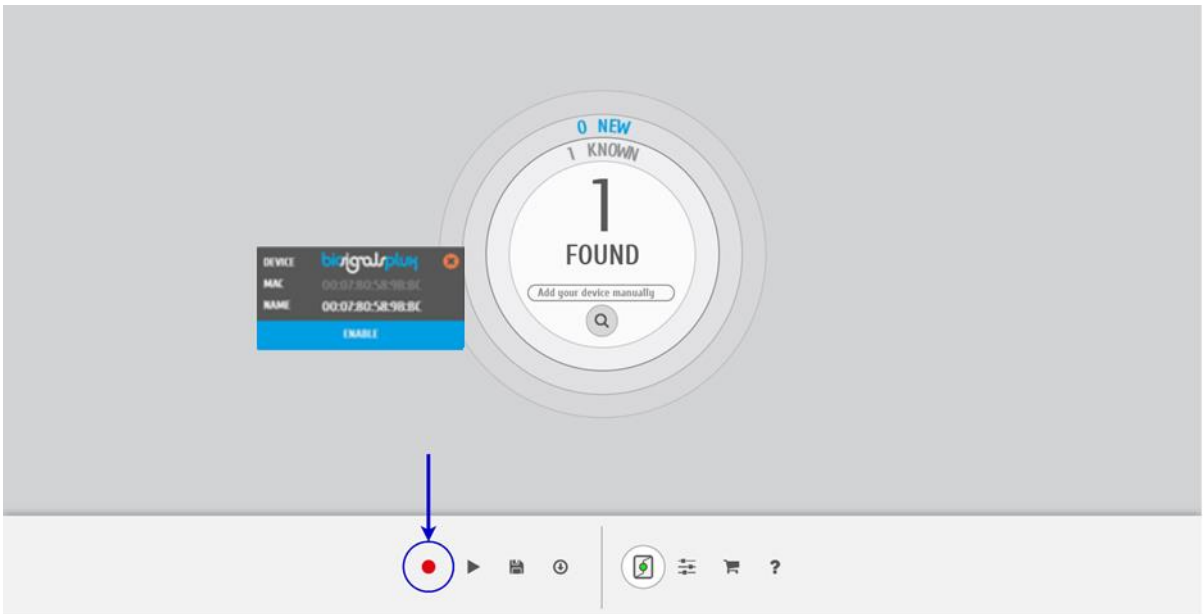

Figure 10: Start the acquisition whenever you're ready.

4. Scientific Publications Using the SENS 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/index.php/learn/publications-comm

Publications

A. Bernardino, C. Vismara, F. Baptista, F. Carnide, S. Oom, S. Bermudez i Badia, E. Gouveia, H. Gamboa, "A Dataset for the Automatic Assessment of Functional Senior Fitness Tests using Kinect and Physiological Sensors", in *Proc. of the 1st International Conference on Technology and Innovation in Sports, Health and Wellbeing* (TISHW), pp. 1-6, 2016

A. Kyrylova, T. Desplenter, A. Escoto, S. Chinchalkar, A. L. Trejos, "Simplified EMG-driven Model for Active-Assisted Therapy," in *IEEE International Conference on Intelligent Robots and Systems, Workshop on Rehabilitation and Assistive Robotics*, 2014

T. Descplenter, A. Kyrylova, T. K. Stanbury, A. Escoto, S. Chinchalkar, A. Trejos, "A wearable mechatronic brace for arm rehabilitation", in *Proc. of the 5th IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics*, pp. 491-496, 2014

A. Reiss, I. Indlekofer, P. Schmidt, K. van Laerhoven, "Deep PPG: Large-Scale Heart Rate Estimation with Convolutional Neural Networks", in *Sensors*, vol. 19, no. 14:3079, pp. 1-27, 2019

I. M. Pires, M. Andrade, N. M. Garcia, R. Crisóstomo, F. Florez-Revuelta, "Measurement of Heel-Rise Test Results using a Mobile Device", in *Proc. of the 2nd International Conference on Physiological Computing Systems*, pp. 9-18, 2015

I. M. Pires, N. M. Garcia, M. Teixeira, "Calculation of Jump Flight Time using a Mobile Device", in *Proc. of the International Conference on Health Informatics* (HEALTHINF), pp. 293-303, 2015

I. P. Machado, A. Gomes, H. Gamboa, V. Paixão, R. Costa, "Human activity data discovery from triaxial accelerometer sensor: Non-supervised learning sensitivity to feature extraction parametrization", in *Information Processing and Management*, vol. 5, no. 2, pp. 204-214, 2015

T. Seeberg, J. Tjønnås, O. Rindal, P. Haugnes, S. Dalgard, Ø. Sandbakk, "A multi-sensor system for automatic analysis of classical cross-country skiing techniques", in *Sports Engineering*, vol. 20, no. 4, pp. 313-327, 2019

H. Myklebust, T. Losnegard, J. Hallén, "Differences in V1 and V2 ski skating techniques described by accelerometers", in *Medicine & Science in Sports*, vol. 24, no. 6, pp. 882-893, 2014

A. Londral, H. Silva, N. Nunes, M. Carvalho, L. Azevedo, "A Wireless User-Computer Interface to Explore Various Sources of Biosignals and Visual Biofeedback for Severe Motor Impairment", in *Journal of Accessibility and Design for All*, vol. 3, no. 2, pp. 118-134, 2013

B. Sañudo, A. Feria, L. Carrasco, M. de Hoyo, R. Santos, H. Gamboa, "Gender Differences in Knee Stability in Response to Whole-Body Vibration", in *Journal of Strength and Conditioning Research*, vol. 26, no. 8, pp. 2156-2165, 2012

5. Safety & Maintenance

5.1. Safety Instructions

Please read the following safety instructions **before** using your **biosignalsplux** system with the **ACC** 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 Temperature sensors to orders@plux.info. If no specification is provided, the standard version of the sensor will be delivered.

Accelerometer Sensor

SKU Reference	PLUX Code	UPC
SENSPRO-ACC	820201205	641945959727
Description		
Accelerometer (ACC) sensor with standard physical characteristics and a random cable sleeve color.		

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.

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