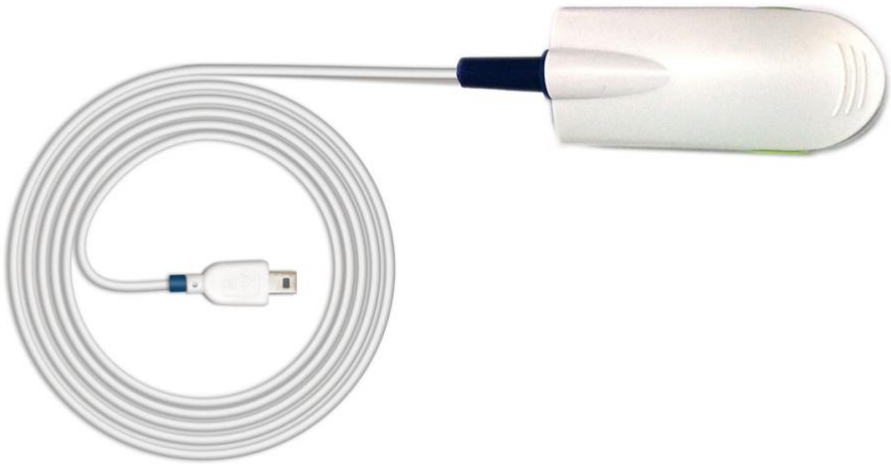
biosignal acquisition tool-kit for advanced research applications

Blood Volume Pulse (BVP) 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 helpdesk@pluxbiosignals.com if there are any variations from your original order.

For regulatory information, please see the **Error! Reference source not found.** at the end of this document.

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1. General Information

1.1. General Description

The biosignalsplux Blood Volume Pulse (BVP) sensor is an optical, non-invasive sensor measures changes in the arterial translucency using the light emitter and detector built into its finger-clip housing.

When the heart pumps blood, the arteries become opaquer, allowing less light to pass from the emitter on the sensor through to the receiver on the other side of finger clip. This variation in light absorption can be used to determine important characteristics of cardiac monitoring (e.g. heart rate) which can afterwards be used for further analysis (e.g. heart rate variation).
Additionally, the clip-on form-factor minimizes interferences from external light sources, enabling reliable signal acquisitions.

Together with the Heart Rate Variability (HRV) add-on for our OpenSignals software, one can easily record and extract meaningful temporal, spectral, and nonlinear signal parameters for further analysis of the acquired sensor data.

Figure 1: biosignalsplux BVP sensor (standard version)

1.2. Typical Unfiltered Sensor Output

Figure 2 shows a typical unfiltered Blood Volume Pulse 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 (relative intensity) using the transfer function found in section Transfer Function (Conversion Formula).

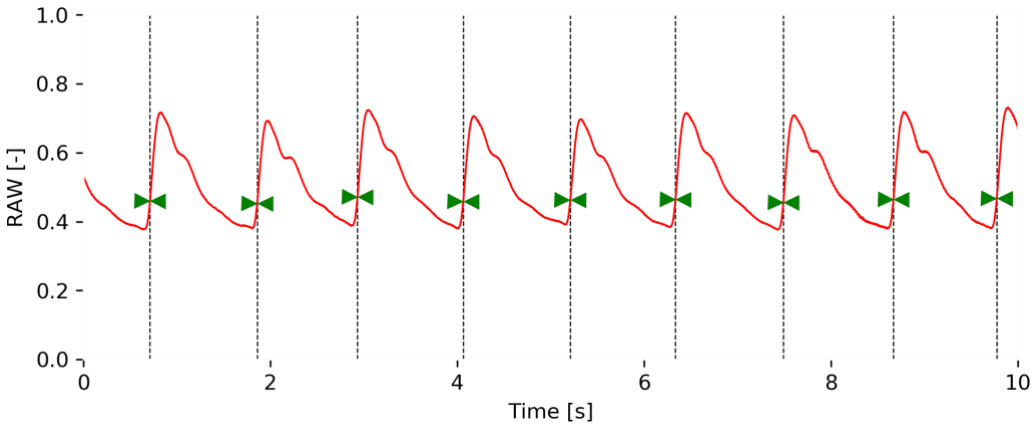

Figure 2: Typical unfiltered sensor output (at rest).

1.3. Sensor Specifications

> Gain:	34	**> LED Wavelength:**	670 nm
> Bandwidth:	0.02-2.1 Hz	**> Consumption:**	~4.8 mA
> Type	Transmittance		

1.4. Features

> Transmittance operating principle
> Optical emitter (red LED) & receiver
> High signal-to-noise ratio
> Medical-grade raw data output
> Unobtrusive & lightweight sensor
> Pre-conditioned analog output
> Ready-to-use & miniaturized form factor

1.5. Applications

> Life sciences studies
> Heart rate & heart rate variability
> Vasoconstriction effect detection
> Physiology studies
> Biofeedback
> Biomedical device prototyping
> Pulse transit time analysis
> Affective computing
> Psychophysiology

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 relative intensity of the acquired BVP signal is preferred or required. The raw digital sensor samples can be converted back into relative intensity using the following formula:

$$BVP = \frac{ADC}{2^n} \quad (1)$$

Valid sensor range: [0, 1]

with: BVP BVP signal in relative intensity
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)

1.7. Physical Characteristics

> W x L x H: 1.0x1.8x0.4cm **> A:** 105.0 ± 0.5cm

> Available sleeve colors: White, Black, Blue, Green, Red, Yellow, Gray, or Brown

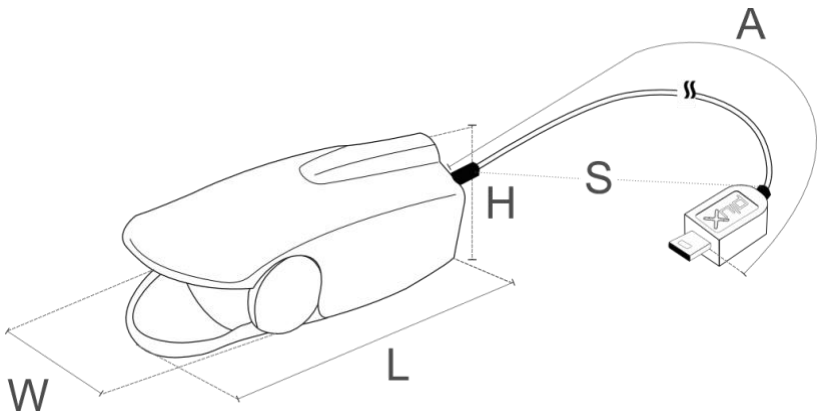

Figure 3: Physical characteristics of the standard BVP sensor.

2. Application Notes

Download Sensor Sample Data

https://support.pluxbiosignals.com/knowledge-base/biosignalsplux-sensor-sample-signals-samples/

The standard version of the Blood Volume Pulse (BVP) sensor is intended for acquisition at the fingertip as shown in Figure 4.

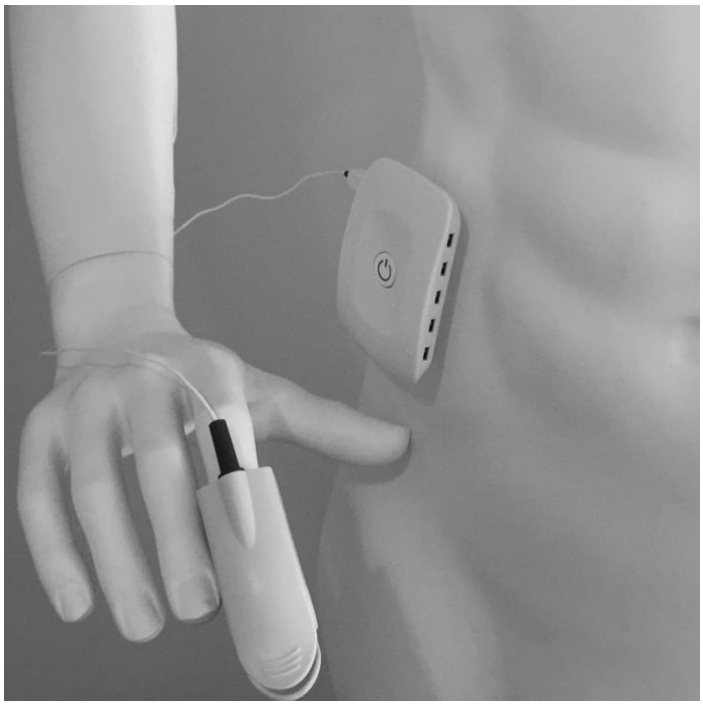

Figure 4: Application of the standard BVP sensor.

This sensor works as a photoplethysmography sensor, which takes advantage of the transmission of radiation trough the blood vessels. This way, given the pulse generated by the blood flowing, the absorbed light generates the well-known signal illustrated in Figure 2.

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

3.1. Connecting the sensor to biosignalsplux Systems

3.1.1. biosignalsplux 4-Channel Hubs

The biosignalsplux BVP 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 an analog input to use it with this device.

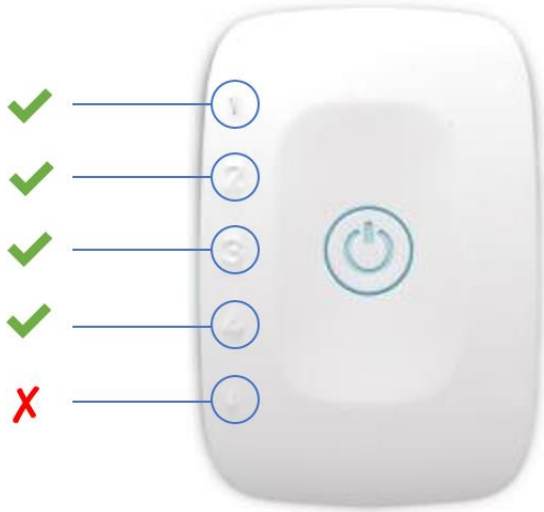

Figure 5: ECG compatible biosignalsplux channels (green checkmarks).

3.1.2. biosignalsplux 8-Channel Hubs

The biosignalsplux BVP 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.

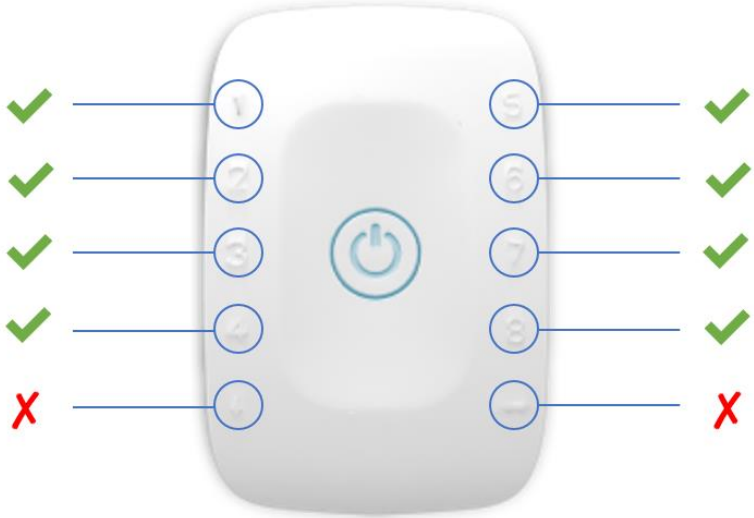

Figure 6: BVP compatible biosignalsplux channels (green checkmarks).

3.1.3. biosignalsplux Solo & Single-Channel openBAN Devices

The biosignalsplux BVP 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 7: Connect the BVP to the analog input channel of the biosignalsplux Solo (openBAN).

3.2. Configuring the Sensor in OpenSignals

Download OpenSignals
https://support.pluxbiosignals.com/knowledge-base/introducing-opensignals-revolution/

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

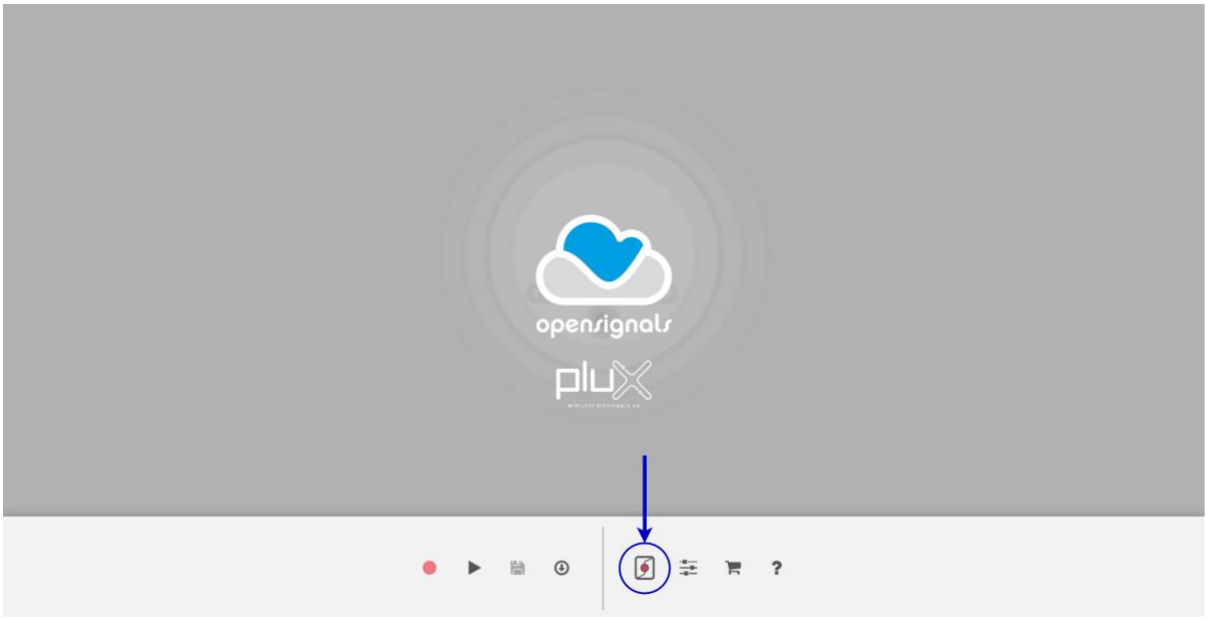

Figure 8: Access the OpenSignals (r)evolution device manager.

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.

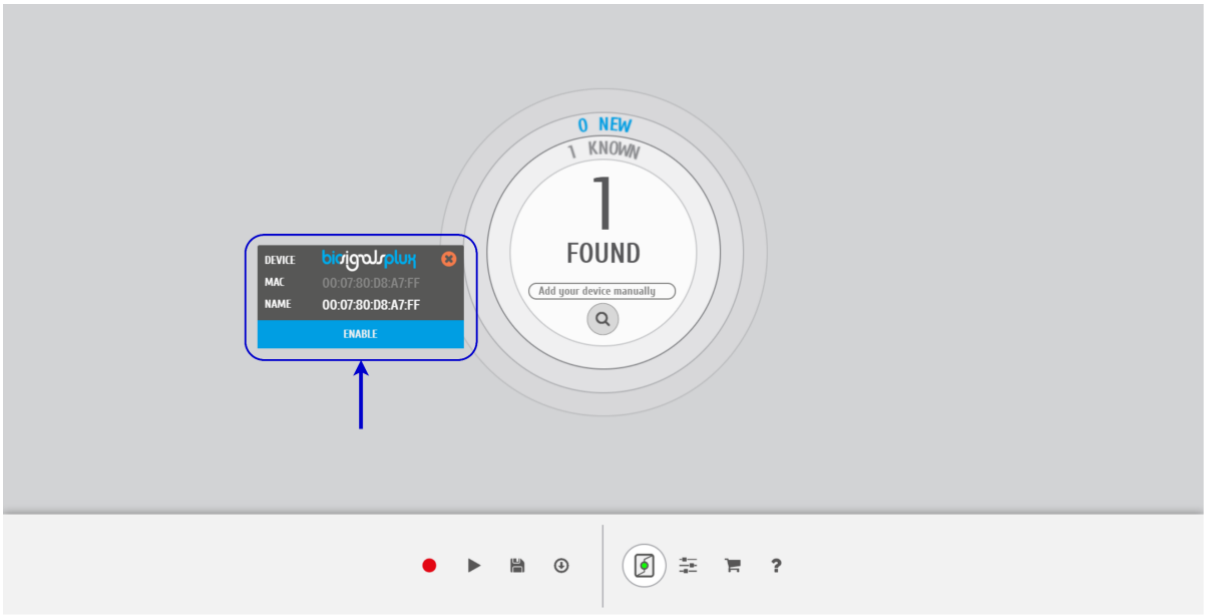

Figure 9: Enabling the device for acquisition.

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

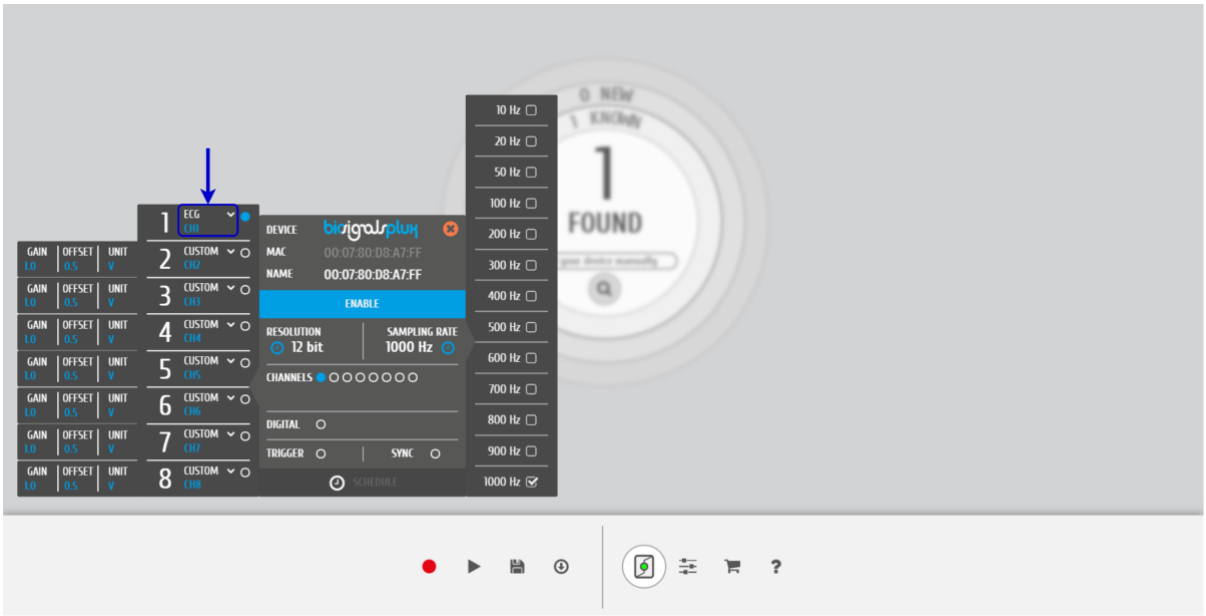

Figure 10: Set the channel type of the channel you have your BVP sensor connected to, to BVP.

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 ***Error! Reference source not found. Error! Reference source not found.*** 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 11: 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 BVP sensor can be applied. Find below a list of the available technical notes and the links to the respective documents.

Download

biosignalsplux Technical Notes - BVP

The purpose of this technical note is to show a typical acquisition of blood volume pulse signal. For this application, a BVP with 35s was recorded with a subject in an upright standing position with the arm suspended at the horizontal direction. To assess the quality of the signal, the Signal-to-Noise (SNR) was calculated.

5. Scientific Publications

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
https://support.pluxbiosignals.com/1352-2/

Publications

H. Silva, H. Ferreira, C. Rocha, L. Rodrigues, Texture Analysis is a Useful Tool to assess the Complexity Profile of Microcirculatory Blood Flow, in *Applied Sciences 2020*, vol. 10, no. 911, pp. 1-11, 2020

D. Osório, R. Viana-Soares, J. Pedro Marto, M. Mendonça, H. Silva, C. Quaresma, M. Viana-Baptista, H.Gamboa, H. Vierira, Autonomic nervous system response to remote ischemic conditioning: heart rate variability assessment, in *BMC Cardiovascular Disorders*, vol. 19, no. 211, 2019

J. Pinto, A. Fred, H. Silva, Biosignal-Based Multimodal Emotion Recognition in a Valence-Arousal Affective Framework Applied to Immersive Video Visualization, in *2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, pp. 3577-3583, 2019

S. Quakinin, S. Eusebio, M. Torrado, H. Silva, I. Nabais, G. Gonçalves, L. Bacelar-Nicolau, Stress reactivity, distress and attachment in newly diagnosed breast cancer patients, in *Health Psychology and Behavioral Medicine*, vol. 3, no. 1, pp. 424-438, 2015

F. Canento, A. Fred, H. Silva, H. Gamboa, A. Lourenço, Multimodal biosignal sensor data handling for emotion recognition, in *Sensors*, pp. 647-650, 2011

6. Safety & Maintenance

6.1. Safety Instructions

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

More information on cleaning instructions can be found here:

https://support.pluxbiosignals.com/knowledge-base/how-do-i-clean-my-plux-products/

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