



biosignal acquisition tool-kit for advanced research applications

user manual



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### **ATTENTION**

please read this manual before using your  
biosignalsplux product

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Please check your system after receiving and before using it the first time, to confirm if it contains all the ordered sensors, accessories and other components. Contact our customer support if there are any variations from your original order.

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## TABLE OF CONTENTS

<b>DISCLAIMER .....</b>	<b>3</b>
<b>1 Your biosignalsplux Kit .....</b>	<b>7</b>
1.1 biosignalsplux Explorer.....	8
1.2 biosignalsplux Researcher .....	10
1.3 biosignalsplux Professional.....	12
1.4 biosignalsplux Force .....	14
1.5 ergoplux Explorer .....	16
1.6 ergoplux Explorer .....	18
<b>2 biosignalsplux HUB.....</b>	<b>20</b>
2.1 4-Channel Hub Specifications .....	21
2.2 8-Channel Hub Specifications .....	22
2.3 Ports and Peripherals .....	23
2.3.1 Button.....	23
2.3.2 Analog Inputs.....	23
2.3.3 Reference .....	23
2.3.4 Digital Port.....	24
2.3.5 Charging Port.....	24
2.3.6 Button Behavior.....	24
2.4 General Device Functionality.....	25
2.4.1 Turning on the Device .....	25
2.4.2 Connecting the Sensors .....	25
2.4.3 Disconnecting the Sensors .....	25
2.4.4 Charging.....	26
2.5 Communication.....	27
2.5.1 Bluetooth.....	27
2.5.2 USB .....	28
<b>3 biosignalsplux Sensors.....</b>	<b>29</b>
3.1 Professional Sensors.....	30
3.1.1 Electromyography (EMG) .....	30
3.1.2 Electrocardiography (ECG) .....	33
3.1.3 Electrodermal Activity (EDA) .....	36
3.1.4 Electroencephalography (EEG) .....	40
3.1.5 Accelerometer (ACC) .....	43
3.1.6 Temperature (TMP) .....	45
3.1.7 Respiration (PZT) .....	47
3.1.8 Force (FSR).....	50
3.1.9 Light (LUX) .....	52
3.2 Advanced Sensors .....	55
3.2.1 Respiration (RIP).....	55
3.2.2 Goniometer (GON) .....	57
3.2.3 Load Cell .....	59
3.2.4 Vaginal Probe (Pelvic EMG Sensor) .....	61
3.2.5 RFID Sensor.....	63
3.2.6 Blood Volume Pulse (BVP).....	65
3.2.7 SpO2 .....	68
3.2.8 fNIRS .....	71
3.2.9 Blood Pressure Reader (BPR).....	74

3.2.10	SpO2 Reader (OSL) .....	76
3.2.11	Glucose Meter Reader (GMR) .....	78
<b>4</b>	<b>Accessories.....</b>	<b>82</b>
4.1	<b>Actuators .....</b>	<b>83</b>
4.1.1	Handheld Switch.....	83
4.1.2	Foot Switch .....	85
4.1.3	Light-Emitting Diode (LED) .....	87
4.2	<b>Synchronization &amp; Additional Digital Ports .....</b>	<b>90</b>
4.2.1	Digital Synchronization Cable .....	90
4.2.2	Multi Sync Splitter .....	92
4.3	<b>3rd Party Compatibilities.....</b>	<b>94</b>
4.3.1	I/O Breakout Cable .....	94
4.3.2	Sensor Breakout PCB .....	95
<b>5</b>	<b>ergoplux.....</b>	<b>96</b>
5.1	<b>Hardware .....</b>	<b>96</b>
5.2	<b>Software .....</b>	<b>97</b>
5.2.1	Video Synchronization Add-On .....	97
5.2.2	Electromyography Analysis Add-On .....	100
5.2.3	Muscle Load Add-On .....	104
5.3	<b>Scientific Background – Muscle Load .....</b>	<b>107</b>
5.3.1	Amplitude Probability Distribution.....	107
5.3.2	Computation.....	107
<b>6</b>	<b>Data Logging.....</b>	<b>110</b>
6.1	<b>Scheduling Offline Acquisitions .....</b>	<b>111</b>
6.1.1	Control by Trigger.....	112
6.1.2	Stop When Full .....	112
6.1.3	Scheduling Start & End Times.....	113
6.1.4	Setting & Clearing Acquisition Schedules .....	114
6.2	<b>Downloading Offline Acquired Data .....</b>	<b>115</b>
6.2.1	Download via Bluetooth .....	115
6.2.2	Download via Fast USB Data Transfer Cable .....	116
6.2.3	Deleting Offline Acquired Data.....	118
<b>7</b>	<b>Bluetooth Setup .....</b>	<b>119</b>
7.1	<b>Windows 7 .....</b>	<b>119</b>
7.2	<b>Windows 8 .....</b>	<b>122</b>
7.3	<b>Windows 10 .....</b>	<b>124</b>
7.4	<b>Linux .....</b>	<b>126</b>
7.4.1	Connecting via System Settings.....	126
7.4.2	Connecting via Terminal .....	130
7.5	<b>Mac OS X.....</b>	<b>133</b>
<b>8</b>	<b>Firmware Updates &amp; Upgrades.....</b>	<b>136</b>
8.1	<b>Checking Firmware Version .....</b>	<b>136</b>
8.2	<b>Updating or Upgrading Firmware .....</b>	<b>137</b>
<b>9</b>	<b>Software &amp; APIs .....</b>	<b>139</b>
9.1	<b>OpenSignals (r)evolution .....</b>	<b>139</b>
9.2	<b>OpenSignals Mobile .....</b>	<b>139</b>
9.3	<b>APIs.....</b>	<b>139</b>
<b>10</b>	<b>Troubleshooting.....</b>	<b>140</b>

<b>10.1</b>	<b>Bluetooth .....</b>	<b>140</b>
10.1.1	Windows 7 & Windows 8 .....	141
10.1.2	Windows 10.....	145
<b>11</b>	<b>Safety &amp; Maintenance.....</b>	<b>151</b>
<b>11.1</b>	<b>Maintenance Recommendations .....</b>	<b>152</b>
11.1.1	Transportation and Storage.....	152
11.1.2	Cleaning.....	153
<b>12</b>	<b>Regulatory &amp; Legal Information .....</b>	<b>154</b>
<b>12.1</b>	<b>Disclaimer .....</b>	<b>154</b>
<b>12.2</b>	<b>Guarantee of Quality &amp; Warranty.....</b>	<b>154</b>
12.2.1	Warranty Voidance.....	154
<b>12.3</b>	<b>Contact &amp; Support.....</b>	<b>156</b>
<b>13</b>	<b>Datasheets .....</b>	<b>157</b>

## 1 Your biosignalsplux Kit



Figure 1: biosignalsplux kit.

*biosignalsplux* systems are available in 4 different kit versions. These versions are listed on the following pages. We recommend you to check and confirm the content of your kit after receiving it and before using it the first time, to identify missing or wrongly shipped components or sensors that vary from your original order. Contact our support if there are any variations from your original order.

## 1.1 biosignalsplux Explorer



Figure 2: biosignalsplux Explorer Kit

This kit contains:

- 1 wireless 4-channel *biosignalsplux* HUB
- 4 professional sensors of your choice
- 1 PLUX proven Bluetooth dongle
- 24 electrodes
- 1 medical grade charger
- 1 portable and rugged storage case with foam cushioning to house all the parts
- OpenSignals (r)evolution signal acquisition and visualization software (download [here](#))
- OpenSignals (r)evolution Real-Time Event Emulation Add-On

Optional components, features, and add-ons<sup>1</sup>:

- 1 digital I/O port
- 8GB internal memory
- Advanced sensors (see *3.2 Advanced Sensors*)
- Accessories (see *4 Accessories*)
- OpenSignals (r)evolution Heart Rate Variability (HRV) Add-On
- OpenSignals (r)evolution Electromyography (EMG) Analysis Add-On
- OpenSignals (r)evolution Electrodermal (EDA) Events Add-On
- OpenSignals (r)evolution Respiration (PZT & RIP) Add-On
- OpenSignals (r)evolution Video Synchronization Add-On

---

<sup>1</sup> OpenSignals (r)evolution add-ons may require specific sensors. Please check the indications given in chapter *9.1 OpenSignals (r)evolution* to confirm that you have the required sensor(s).

## 1.2 biosignalsplux Researcher



Figure 3: biosignalsplux Researcher Kit

This kit contains:

- 1 wireless 8-channel *biosignalsplux* HUB
- 8 professional sensors of your choice
- 1 PLUX proven Bluetooth dongle
- 24 electrodes
- 1 medical grade charger
- 1 portable and rugged storage case with foam cushioning to house all the parts
- 8h personalized technical support
- OpenSignals (r)evolution signal acquisition and visualization software (download [here](#))



- OpenSignals (r)evolution Real-Time Event Emulation Add-On
- OpenSignals (r)evolution Video Synchronization plug-in (pre-activated in OpenSignals)

Optional components, features, and add-ons<sup>2</sup>:

- 8GB internal memory
- Advanced sensors (see *3.2 Advanced Sensors*)
- Accessories (see *4 Accessories*)
- OpenSignals (r)evolution Heart Rate Variability (HRV) Add-On
- OpenSignals (r)evolution Electromyography (EMG) Analysis Add-On
- OpenSignals (r)evolution Electrodermal (EDA) Events Add-On
- OpenSignals (r)evolution Respiration (PZT & RIP) Add-On

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<sup>2</sup> OpenSignals (r)evolution add-ons may require specific sensors. Please check the indications given in chapter *9.1 OpenSignals (r)evolution* to confirm that you have the required sensor(s).



### 1.3 biosignalsplux Professional



Figure 4: biosignalsplux Professional Kit.

This kit contains:

- 1 wireless 8-channel *biosignalsplux* HUB
- 8 professional sensors of your choice
- 1 PLUX proven Bluetooth dongle
- 8GB internal memory
- 24 electrodes
- 1 medical grade charger
- 1 portable and rugged storage case with foam cushioning to house all the parts
- 16h personalized technical support
- Fast USB data transfer cable

- OpenSignals (r)evolution signal acquisition and visualization software (download [here](#))
- OpenSignals (r)evolution Real-Time Event Emulation Add-On
- OpenSignals (r)evolution Heart Rate Variability (HRV) Add-On
- OpenSignals (r)evolution Electromyography (EMG) Analysis Add-On
- OpenSignals (r)evolution Electrodermal (EDA) Events Add-On
- OpenSignals (r)evolution Respiration (PZT & RIP) Add-On
- OpenSignals (r)evolution Video Synchronization Add-On

Optional components and features<sup>3</sup>:

- Advanced sensors (see *3.2 Advanced Sensors*)
- Accessories (see *4 Accessories*)

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<sup>3</sup> OpenSignals (r)evolution add-ons may require specific sensors. Please check the indications given in chapter 9.1 *OpenSignals (r)evolution* to confirm that you have the required sensor(s).

## 1.4 biosignalsplux Force



Figure 5: biosignals Force

This kit contains:

- 1 wireless 4-channel *biosignalsplux* HUB with 8GB internal memory
- 4 load cell sensors (200Kg per sensor)
- 1 PLUX Bluetooth dongle
- 8GB internal memory
- 1 medical grade charger
- 1 sturdy aluminium plate (45x45cm)
- OpenSignals (r)evolution signal acquisition and visualization software (download [here](#))
- OpenSignals (r)evolution Real-Time Event Emulation Add-On

- OpenSignals (r)evolution Center of Mass Analysis Add-on

Optional components, features, and add-ons:

- 1 digital I/O port
- Advanced sensors (see *3.2 Advanced Sensors*)
- Accessories (see *4 Accessories*)
- OpenSignals (r)evolution Video Synchronization Add-On

## 1.5 ergoplux Explorer



ergoplux Explorer was designed to objectively track and measure work-related stress on workers conducting physical work processes by providing reliable data for ergonomists to detect, prevent, and/or improve high-risk work activates. ergoplux explorer aims to help decrease and prevent the amount of work-related musculoskeletal disorders.

This kit objectively measures muscular load according to released standards (ISO 5349-1:2001). It uses the *OpenSignals (r)evolution* software to acquire and visualize data from up to 8 electromyography sensors simultaneously and the *Electromyography Analysis* add-on to extract statistical information from the acquired signals to evaluate the stress workers are exposed to in further detail.

This kit contains:

- 1x Wireless 4-channel hub (see specs below)
- 4x Professional sensors of your choice
- 24x Pre-gelled electrodes
- 1x Bluetooth dongle
- 1x Medical-grade charger
- 1x Portable and rugged storage case with foam cushioning to house all the parts
- OpenSignals (r)evolution signal acquisition and visualization software (download [here](#))
- OpenSignals (r)evolution Real-Time Event Emulation Add-On
- Muscle Load add-on for OpenSignals
- VideoSync add-on for OpenSignals
- Cross-platform APIs



## 1.6 ergoplux Explorer



ergoplux Researcher was designed to objectively track and measure work-related stress on workers conducting physical work processes by providing reliable data for ergonomists to detect, prevent, and/or improve high-risk work activities. ergoplux explorer aims to help decrease and prevent the amount of work-related musculoskeletal disorders.

This kit objectively measures muscular load according to released standards (ISO 5349-1:2001). It uses the *OpenSignals (r)evolution* software to acquire and visualize data from up to 8 electromyography sensors simultaneously and the *Electromyography Analysis* add-on to extract statistical information from the acquired signals to evaluate the stress workers are exposed to in further detail.

ergoplux Researcher uses the *OpenSignals (r)evolution* software and the *Muscle Load Analysis* software add-on to track the muscular stress of workers by acquiring electromyography signals (up to 8 sensors simultaneously) and by analyzing the muscle contraction intensities over time (see probability distribution function of amplitude (APDF)).

This kit contains:

- 1x Wireless 8-channel hub (see specs below)
- 8x Professional EMG sensors
- 24x Pre-gelled electrodes
- 1x Bluetooth dongle
- 1x Medical-grade charger
- 1x Portable and rugged storage case with foam cushioning to house all the parts
- 4h of technical support & training
- OpenSignals (r)evolution software for real-time acquisition & offline visualization
- EMG add-on for OpenSignals
- Muscle Load add-on for OpenSignals
- Video Sync add-on for OpenSignals
- Cross-platform APIs



## 2 biosignalsplux HUB



Figure 6: biosignalsplux hub

The *biosignalsplux* hub is the 4 or 8-channel device that collects and digitizes all signals from the sensors and accessories and transmits them via Bluetooth to the computer, where they are recorded and visualized in real-time. The channels support up to 16-bit resolution and 3000Hz sampling frequency per channel, i.e. up to 8 channels with 3000 16-bit samples per channel per second, or 4000Hz sampling frequency per channel when using only up to 3 channels simultaneously.

*biosignalsplux* is compatible with all available *biosignalsplux* professional sensors (3.1 *Professional Sensors*), advanced sensors (3.2 *Advanced Sensors*), and accessories. Devices with internal memory do also allow options for onboard data logging features, without the of a permanent Bluetooth connection.

### Features

- > Designed for advanced biosignal research
- > Medical-grade raw data acquisition
- > Ready to use in- & out-of-the-lab
- > Sensor auto-detection
- > Bluetooth streaming capability for online acquisitions
- > Internal memory for offline acquisitions

### Intended Use for Research Applications

- > Life sciences studies
- > Biomedical research
- > Human-Computer-Interaction
- > Sports sciences & biomechanics
- > Robotics & Cybernetics
- > biomechanics
- > Ergonomics

## 2.1 4-Channel Hub Specifications



Figure 7: 4-channel biosignalsplux hub.

The 4-channel hub is available in the *biosignalsplux* Explorer and Force Platform kits and enables the usage of up to 4 sensors simultaneously. The standard version of this hub does not have an internal memory and a digital port which allows the usage of *biosignalsplux* accessories (see chapter 4 *Accessories* for more information). However, these features can be added to a 4-channel device. Contact our support for more information if you need to add these features (see 12.3 *Contact & Support*).

For detailed specifications check the table below and the *biosignalsplux* datasheet at the end of this manual (see annexes).

### Specifications

Analog Inputs:	4 (16-bit per channel)
Digital Ports:	none (optionally available)
Common Ground:	1
Sampling Rate:	up to 3000Hz (per channel); 4000Hz for up to 3 channels
Internal Memory:	none; 8GB optionally available (stores up to ~111h)
Communication:	Bluetooth 2.0+EDR (Class II); USB cable to download stored data from memory (optional extra)
Bluetooth Range:	up to ~10m (in line of sight)
Battery:	700mA 3.7V LiPo rechargeable (up to 12h in continuous streaming)
Hub Size:	54x85x10mm
Weight:	45g

## 2.2 8-Channel Hub Specifications



Figure 8: 8-channel biosignalsplux hub.

The 8-channel hub is available in the *biosignalsplux* Researcher (see 1.2 *biosignalsplux* Researcher) and *biosignalsplux* Professional (see 1.3 *biosignalsplux* Professional) kits and enables the usage of up to 8 sensors and up to 3 accessories (using the multi sync cable; see 4.2 *Synchronization & Additional Digital Ports* for more information) simultaneously.

The hub included in the *biosignalsplux* Professional kit comes with 8GB of internal memory. Internal memory is optionally available for the hub of the *biosignalsplux* Researcher kit. Contact our support for more information if you need to add internal memory to your device (see 12.3 *Contact & Support*)

For detailed specifications check the table below and the *biosignalsplux* datasheet at the end of this manual (see annexes).

### Specifications

Analog Inputs:	8 (16-bit per channel)
Digital Ports:	1
Common Ground:	1
Sampling Rate:	up to 3000Hz (per channel); 4000Hz for up to 3 channels
Internal Memory:	8GB optionally available (stores up to ~111h) (optional for the <i>biosignalsplux</i> Researcher Kit)
Communication:	Bluetooth 2.0+EDR (Class II); USB cable to download stored data from memory (optional extra)
Bluetooth Range:	up to ~10m (in line of sight)
Battery:	700mA 3.7V LiPo rechargeable (up to 12h in continuous streaming)
Hub Size:	54x85x10mm
Weight:	45g

## 2.3 Ports and Peripherals

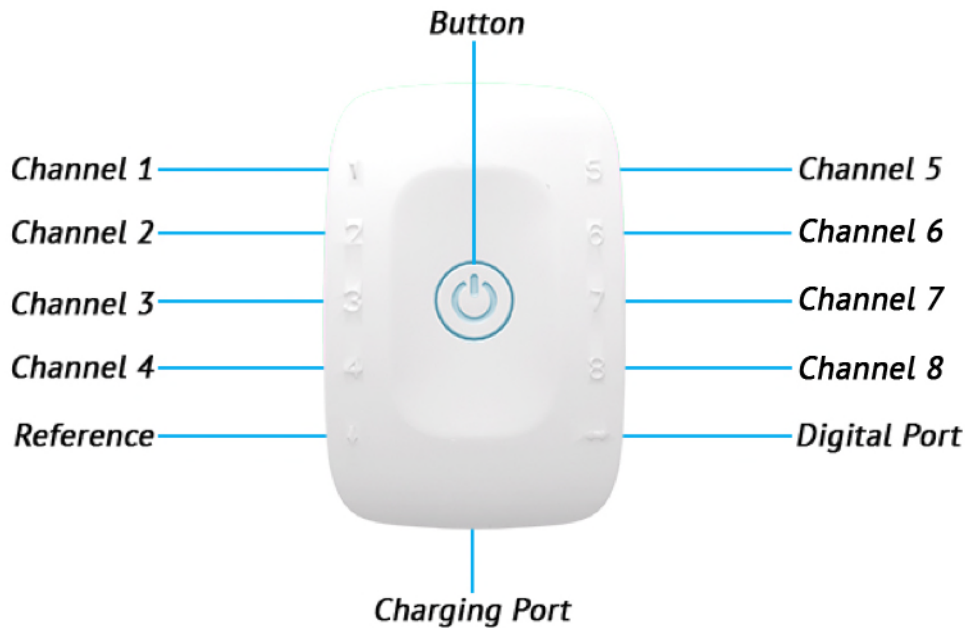


Figure 9: biosignalsplux ports and the button.

### 2.3.1 Button

The button is used to turn the device on and off and to display device status' using the built-in LED (see 2.3.6 *Button Behavior*).

### 2.3.2 Analog Inputs

The *biosignalsplux* hub has 4 or 8 analog ports to connect up to 4 or 8 *biosignalsplux* or 3<sup>rd</sup> party sensors to the hub (see 3 *biosignalsplux* Sensors for more information about the sensors). All channels are synchronously and simultaneously acquired.

### 2.3.3 Reference

The reference port allows you to connect one single lead ground cable to share a common reference point for all sensors. However, some sensors (e.g., ECG and EEG) have their own ground/reference electrodes, which can be used instead. A common ground connection is, for example, useful in applications that require multiple sensors that share the same reference point (e.g. multiple EMG sensors).

Additionally, this port is used to connect the USB adapter for the *fast USB data transfer cable* to download offline acquired signal from the internal memory of *biosignalsplux* devices (see 6 *Data Logging* and 6.2.2 *Download via Fast USB Data Transfer Cable*).

### 2.3.4 Digital Port

The digital port enables the usage of *biosignalsplux* accessories listed in chapter 4 *Accessories* (e.g., trigger buttons to manually mark events in your acquisitions or a synchronization cables to connect several *biosignalsplux* for synchronized multi-device acquisitions).

### 2.3.5 Charging Port

The charging port is designed to charge your device using the medical-grade *biosignalsplux* charger which comes with your kit. Please read the information displayed in the 2.4.4 *Charging* section before using the *biosignalsplux* charger and follow the indicated instructions when charging your *biosignalsplux* device(s) to prevent any damage to the user or the system due to problems occurring during the charging process.

#### **WARNING**

Do not use the *biosignalsplux* device during the charging process.

### 2.3.6 Button Behavior

The button at the center of the *biosignalsplux* hub enables basic control of the device. Please read the *biosignalsplux* hub datasheet to get information about the button behavior (see 13 *Datasheets*).

## 2.4 General Device Functionality

### 2.4.1 Turning on the Device

In order for the device to work, it must be turned on. Turning on the device can be done by pressing the button in the center of the *biosignalsplux* hub. After being turned on, the LED status light will blink once per second (green).



Figure 10: *biosignalsplux* center button.

### 2.4.2 Connecting the Sensors

Sensors have to be connected to channel 1 to 4 or 1 to 8 (number of channels depends on each *biosignalsplux* hub) in order to work properly. Do not connect the sensors to the digital or common ground port, unless it is stated otherwise in the sensor datasheet or in the *3 biosignalsplux Sensors* chapter. The reference electrode/ground cable should be connected to the common ground port (see *Figure 6* or *Figure 11*).

When connecting the sensors, pay attention to where the cables go to avoid device damages or disrupting the user's movements.

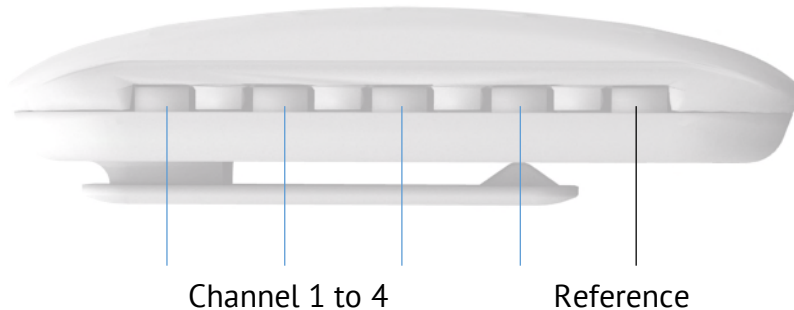


Figure 11: *biosignalsplux* side view.

### 2.4.3 Disconnecting the Sensors

Disconnect the sensors according to the recommendations displayed below, to avoid damaging the *biosignalsplux* device or the sensors:

- don't twist the sensor while disconnecting
- don't apply upward force or pull the cable
- use minimal force to disconnect
- hold the plug firmly and pull it out
- don't pull the cable

## 2.4.4 Charging

### WARNING

Do not use the *biosignalsplux* device during the charging process.

*biosignalsplux* has a battery lifetime of up to 12 hours in continuous usage. Note, that the lifetime might vary depending on the number of active sensors and/or accessories. The built-in LED will light up red if the battery is running low until the device stops working.

To recharge, connect the *biosignalsplux* charger to the device's charging port and to a power outlet (see *Figure 12*). The charging process will take approximately 2 ½ hours to fully charge the battery. The button will light red while charging (steady light when turned off, and flashing red when acquiring or in stand by state), and the red color will turn off once the battery is fully charged.



Charging Port

*Figure 12: Charging port.*

The suitable room temperature when charging the device must be between 10°C and 35°C to prevent device or user related damages during the charging process.

### WARNING

Unplug the charger from the wall outlet if the battery/device overheats (reaching 60°C) and immediately get in contact with PLUX's Technical Assistance.

### NOTE

The red LED will be switched on if an error occurs during the charging process.

In this case, unplug the charger from the wall outlet and plug it in again to complete the charging process correctly. Please get in contact with our support if the error remains permanently.

## 2.5 Communication

The communication with *biosignalsplux* devices is done via Bluetooth or USB. However, the USB communication is used to download offline acquired data only, while Bluetooth is used to configure the device, to acquire and transmit sensor signals in real-time to the computer, and to download offline acquired data which is stored on the internal memory of the *biosignalsplux* device.

### 2.5.1 Bluetooth

*biosignalsplux* uses Bluetooth Class II to communicate with the computer and to transmit the acquired sensor data. Since most internal Bluetooth modules are not designed to support high transfer rates as those are needed when acquiring and streaming signals using *biosignalsplux*, we strongly recommend using the PLUX Bluetooth dongle (which comes with your *biosignalsplux* kit) to prevent any communication issues or connection losses. These dongles have been tested and verified by PLUX to work properly with any *biosignalsplux* device.

The Bluetooth dongle can be found in our store if several dongles are needed (e.g. to use *biosignalsplux* on several computers without having to change the Bluetooth dongle every time another computer's being used<sup>4</sup>).

<https://store.plux.info/biosignalsplux-accessories/368-bitalino-proven-bluetooth-dongle-820201511.html>

Instructions on how to connect *biosignalsplux* via Bluetooth to the computer can be found in the 7 *Bluetooth Setup* section.

If you're experiencing a great number of connection loss events, reconnection problems, missing samples or similar problems, your internal Bluetooth module might be being used for data transmission or your Bluetooth dongle might be configured to use the wrong Bluetooth stack. Instructions to set up the correct Bluetooth stack and to solve such problems can be found in the 10.1 Bluetooth section of this manual

See the table on the following page for detailed Bluetooth specifications of the internal Bluetooth module of *biosignalsplux* devices.

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<sup>4</sup> biosignalsplux can only be connected to one computer at a time



<b>Operating frequency range</b>	2400 – 2483.5 MHz ISM Band
<b>Modulation method</b>	GFSK (1 Mbps) P/4 DQPSK (2Mbps)
<b>Hopping</b>	1600 hops/s, 1 MHz channel space
<b>Transmission power</b>	Min: -11 dBm Max: +3 dBm
<b>Antenna peak gain (XZ-V)</b>	0.5dBi typical
<b>Average antenna gain (XZ-V)</b>	-0.5 dBi typical
<b>Antenna VSWR</b>	2 max
<b>Certifications</b>	Bluetooth, CE, FCC, IC, Japan and South Korea

Table 1: Specifications of biosignalsplux devices' internal Bluetooth modules.

### 2.5.2 USB

The *biosignalsplux* USB adapter and the fast USB data transfer cable *biosignalsplux* accessories allow downloading offline acquired data stored in the internal memory of biosignalsplux devices. For this purpose, the USB adapter must be connected to the reference port of your *biosignalsplux* device (see 2.3.3 Reference).

Full instructions on how to access and download data from the internal memory of your device can be found in the chapters 6.2 *Downloading Offline Acquired Data* and 6.2.2 *Download via Fast USB Data Transfer Cable*.

### 3 biosignalsplux Sensors

*biosignalsplux* has a large variety of compatible professional and advanced sensors. While 4 or 8 professional sensors are already included in the *biosignalsplux* kits, advanced sensors can be bought additionally to extend the number of acquirable biosignals.

The entire updated list of *biosignalsplux* sensors can be accessed via the following link:

<http://biosignalsplux.com/index.php/en/products/sensors>

#### **WARNING**

Do not use damaged sensors, devices or components, as this can cause serious injuries and device damages. Contact PLUX's Technical Assistance to report such issues and report malfunctioning devices or sensors.

#### **NOTE**

Please review the sensor datasheets (see annexes) for more detailed specifications.

#### **NOTE**

The sensor configuration for *biosignalsplux* devices are demonstrated by using PLUX's *OpenSignals (r)evolution* software. Please review the software manual for more detailed information about how to configure your device when using *OpenSignals*.

## 3.1 Professional Sensors

### 3.1.1 Electromyography (EMG)

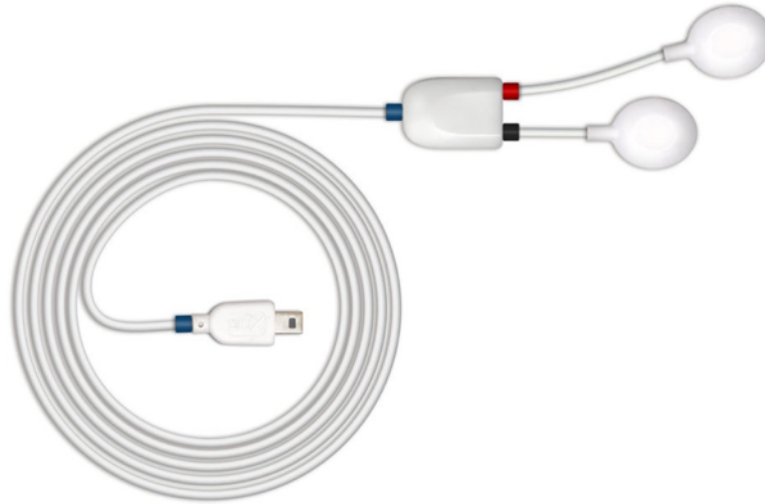


Figure 13: EMG sensor.

Our low-noise ECG local differential triode configuration enables fast application and unobtrusive data acquisition (although custom electrode cable configurations are available). The state-of-the-art design of the analog frontend on this sensor is specifically targeted at analyzing minutiae in the data. Together with the Heart Rate Variability (HRV) plugin on our OpenSignals software, one can easily record and extract meaningful information.

#### Electrode cables & sleeves

The electrode cables of this sensor can be connected to electrodes with integrated stud connectors. The colored plastic sleeves on each electrode cable indicate which electrode must be connected to the positive or negative electrode cable (see Table 2).

Electrode Cable	+	-
Sleeve Color	Red	Black

Table 2: Color coding of the electrode cable sleeves.

#### How to connect your sensor to your biosignalsplux

EMG sensors can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*).

This EMG sensor has no built-in reference electrode. We recommend connecting a reference electrode the reference input of your device (see 2.3.3 *Reference*) which can

then be used as reference signal for your EMG signal(s). For optimal signal acquisition, place your ground electrode on a region of the body with low level of muscle activity.

### How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your EMG sensor connected to. Select the channel of your EMG sensor and select *EMG* out of the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field). No additional set up is needed for the reference electrode inside *OpenSignals (r)evolution*.

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 14* (here: EMG connected to channel 1).

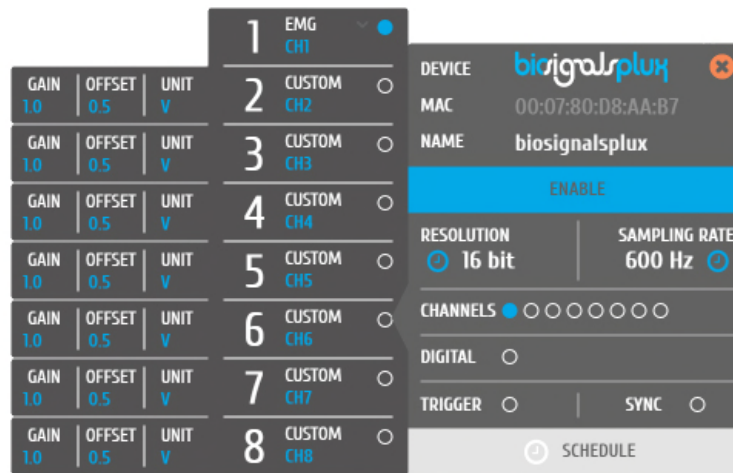


Figure 14: EMG configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in *Figure 15*.

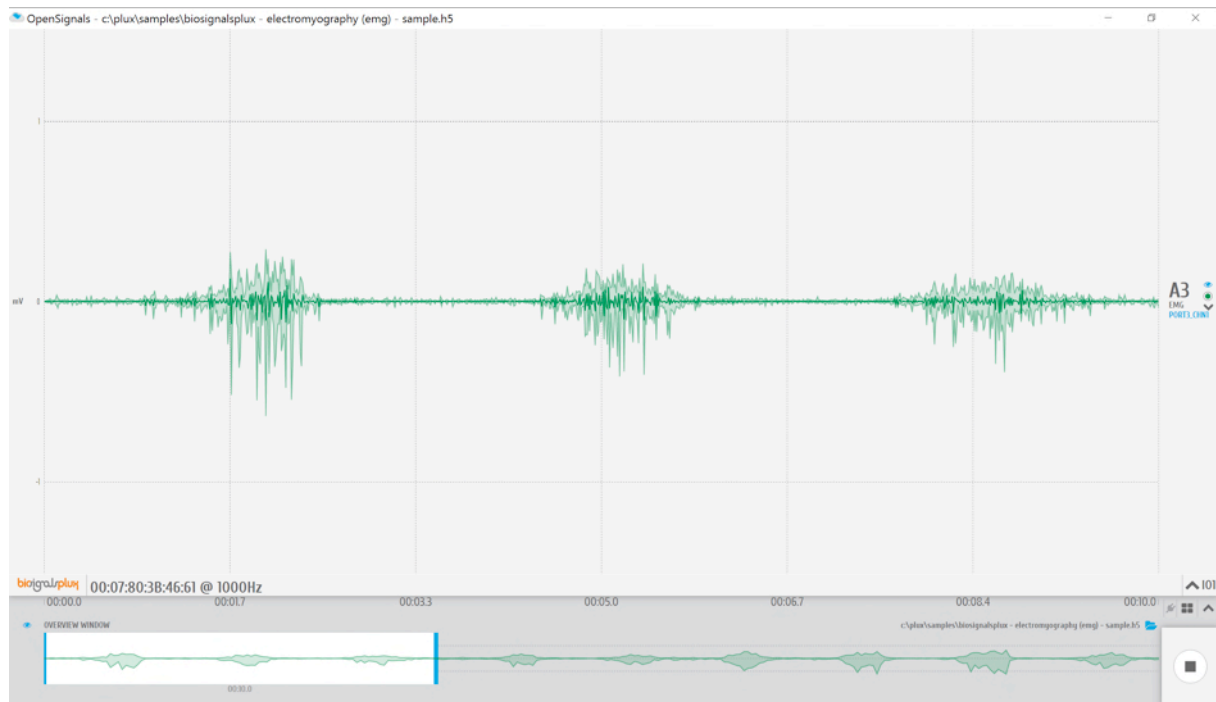


Figure 15: biosignalsplux EMG sensor sample.

### **OpenSignals (r)evolution Add-On: Electromyography Analysis**

The *Electromyography Analysis* add-on is able to extract useful statistical information from EMG data acquired with this EMG sensor. This add-on's automatic onset detection algorithm enables the analysis of each individual muscle action even, in addition to the overall analysis of the recording session. Timings analysis is also done for each activation to a reference muscle.

This add-on is included in the *biosignalsplux Professional* kit (see 1.3 *biosignalsplux Professional*) and can be bought additionally for the use with *biosignalsplux* hubs and wearables which can be used with this EMG sensor.

Please visit the following website for more information about this add-on:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### **Sensor specifications**

Please read the datasheet of the EMG sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/EMG\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/EMG_Sensor_Datasheet.pdf)

### 3.1.2 Electrocardiography (ECG)

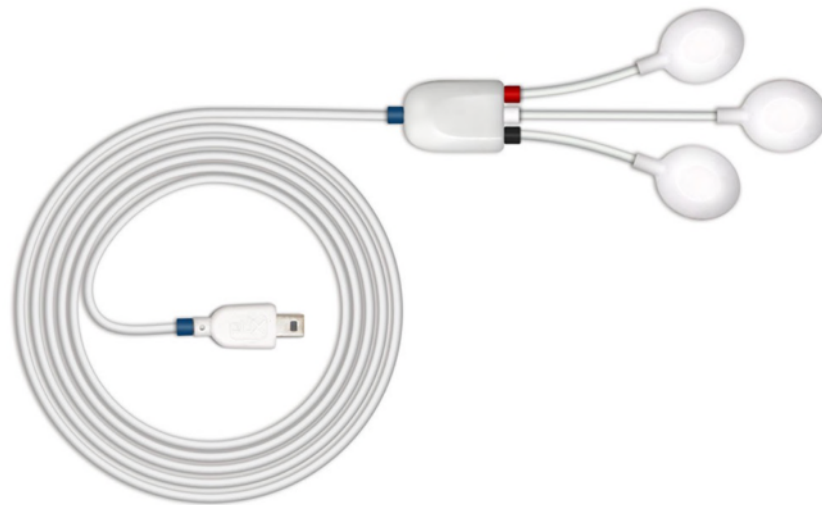


Figure 16: ECG sensor.

Our low-noise ECG local differential triode configuration enables fast application and unobtrusive data acquisition (although custom electrode cable configurations are available). The state-of-the-art design of the analog frontend on this sensor is specifically targeted at analyzing minutiae in the data. Together with the Heart Rate Variability (HRV) plugin on our OpenSignals software, one can easily record and extract meaningful information.

#### Electrode cables & sleeves

The electrode cables of this sensor can be connected to electrodes with integrated stud connectors. The colored plastic sleeves on each electrode cable indicate which electrode must be connected to the positive, negative or reference electrode cable (see Table 3).

Electrode Cable	+	-	Reference
Sleeve Color	Red	Black	White

Table 3: Color coding of the electrode cable sleeves.

#### How to connect your sensor to your biosignalsplux

ECG sensors can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*).

This ECG sensor has a built-in reference electrode. An additional reference electrode which can be connected to the reference input of your device is not needed but can still be used to work with this sensor (see 2.3.3 *Reference*).

#### How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your ECG sensor connected to. Select the channel of your ECG sensor and select *ECG* out of the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field). No additional set up is needed for the reference electrode inside *OpenSignals (r)evolution*.

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 17* (here: ECG connected to channel 1).

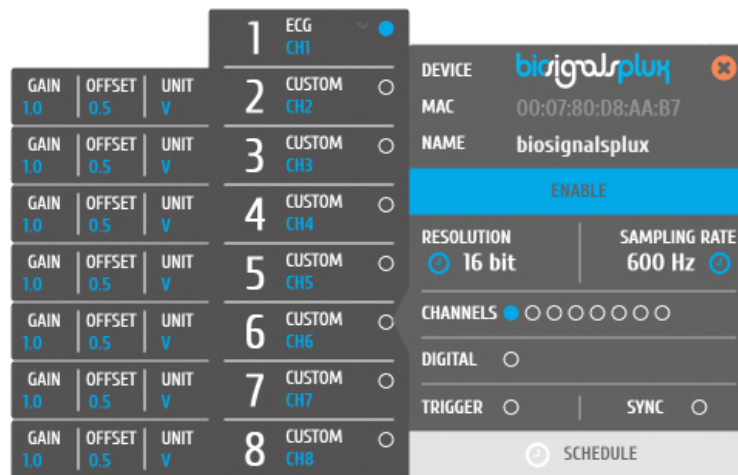


Figure 17: ECG configuration in *OpenSignals*.

If configured correctly, your acquired signals should be similar to the signal displayed in *Figure 18*.

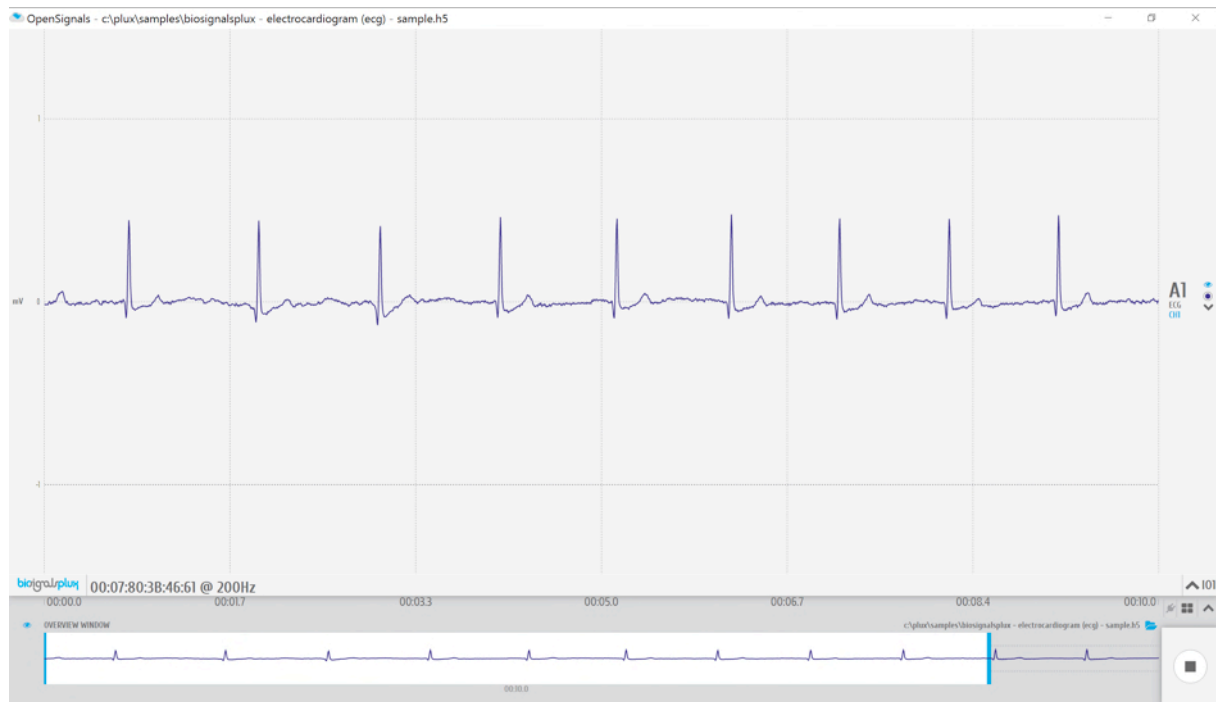


Figure 18: biosignalsplux ECG sensor sample.

### OpenSignals (r)evolution Add-On: Heart Rate Variability

The *Heart Rate Variability* add-on provides important quantitative markers related with the sympathetic or vagal activity. This plugin enables the seamless extraction and analysis of temporal, spectral, and non-linear parameters from sensor data acquired with this ECG sensor (or the blood volume pulse sensor; see 3.2.6 *Blood Volume Pulse (BVP)*).

This add-on is included in the *biosignalsplux Professional* kit (see 1.3 *biosignalsplux Professional*) and in the [cardioBAN wearable](#) but it can also be bought additionally for the use with *biosignalsplux* hubs and wearables which can be used with this ECG sensor.

Please visit the following website for more information about this add-on:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### Sensor specifications

Please read the datasheet of the ECG sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/ECG\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/ECG_Sensor_Datasheet.pdf)



### 3.1.3 Electrodermal Activity (EDA)

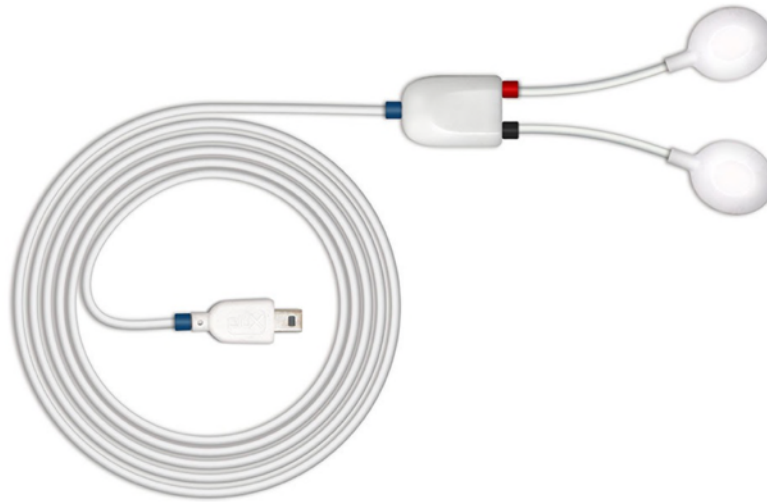


Figure 19: EDA sensor.

Our EDA sensor is capable of accurately measuring the skin activity with high sensitivity in a miniaturized form factor. The low-noise signal conditioning and amplification circuit design provides optimal performance in the detection of even the most feeble electrodermal skin response

#### **How to connect your sensor to your biosignalsplux**

EDA sensors can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*).

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your EDA sensor connected to. Select the channel of your EDA sensor and activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

*OpenSignals (r)evolution* offers two modes that are designed for different applications for EDA sensors that can be selected in the dropdown menu which can be accessed via the channel field (click on the arrow in the channel's field that appears when you hover over the channel's field).

The *EDA* option is designed to work with applications where the EDA sensor is placed, for example, on the hand of the subject. If you plan to use the EDA sensor on the arm of a subject, we recommend selecting the *EDA.ARM* configuration to ensure high quality data acquisition.

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 20* (here: EDA connected to channel 1 and EDA on arm configuration connected to channel 2).

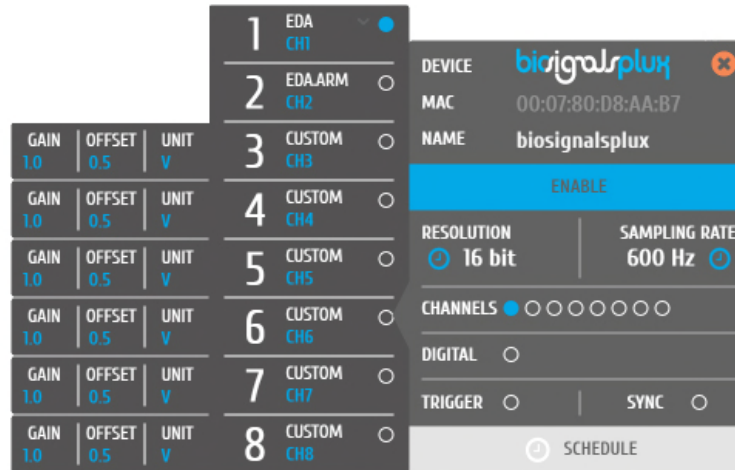


Figure 20: EDA configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in *Figure 21*.

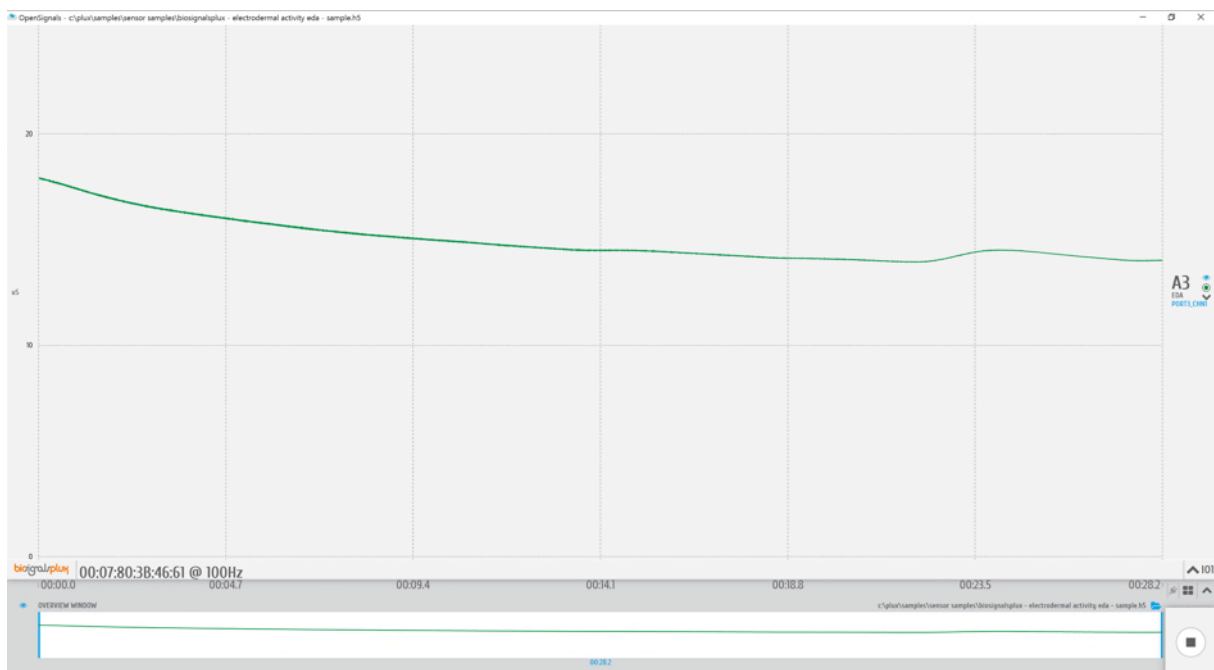


Figure 21: biosignalsplux EDA sensor sample.

### OpenSignals (r)evolution Add-On: Electrodermal Activity Events

The *Electrodermal Activity Events* add-on has been designed to compute overall statistics, basic spectral analysis, and extract typical event-related phasic features from sensor data acquired with this EDA sensor.

This add-on is included in the *biosignalsplux Professional* kit (see 1.3 *biosignalsplux Professional*) and can also be bought additionally for the use with *biosignalsplux* hubs and wearables which can be used with this EDA sensor.

Please visit the following website for more information about this add-on:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### **Sensor specifications**

Please read the datasheet of the EDA sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/EDA\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/EDA_Sensor_Datasheet.pdf)

### 3.1.4 Electroencephalography (EEG)

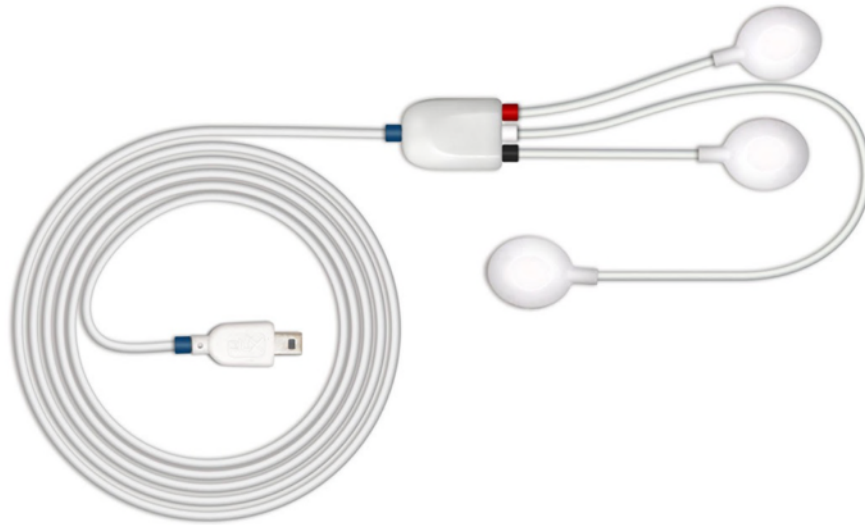


Figure 22: EEG sensor.

Our low-noise ECG local differential triode configuration enables fast application and unobtrusive data acquisition (although custom electrode cable configurations are available). The state-of-the-art design of the analog frontend on this sensor is specifically targeted at analyzing minutiae in the data. Together with the Heart Rate Variability (HRV) plugin on our OpenSignals software, one can easily record and extract meaningful information.

#### Electrode cables & sleeves

The electrode cables of this sensor can be connected to electrodes with integrated stud connectors. The colored plastic sleeves on each electrode cable indicate which electrode must be connected to the positive, negative or reference electrode cable (see Table 4).

Electrode Cable	+	-	Reference
Sleeve Color	Red	Black	White

Table 4: Color coding of the electrode cable sleeves.

#### How to connect your sensor to your biosignalsplux

The EEG sensors can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*).

This EEG sensor has a built-in reference electrode cable. An additional reference electrode which can be connected to the reference input of your device is not needed but can still be used to work with this sensor (see 2.3.3 *Reference*) and useful when using multiple EEG sensors during an acquisition. For optimal signal acquisition, place your reference electrode on a region of the body with low level of muscle activity.

## How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your EEG sensor connected to. Select the channel of your EEG sensor and select *EEG* out of the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field). No additional set up is needed for the reference electrode inside *OpenSignals (r)evolution*.

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 23* (here: EEG connected to channel 1).

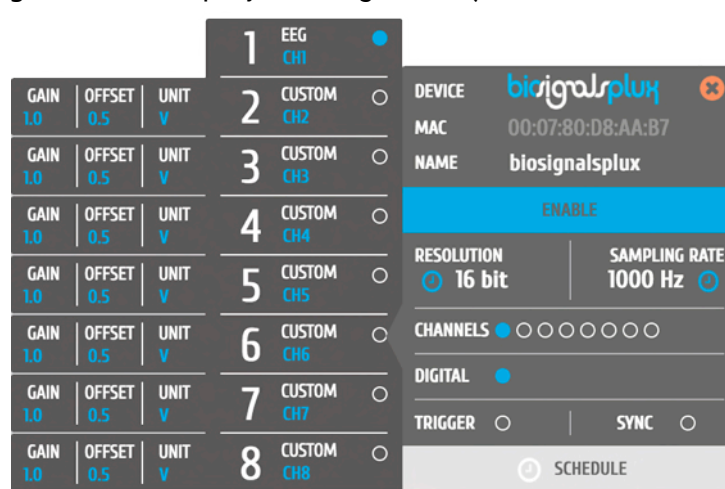


Figure 23: EEG configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in *Figure 24*.

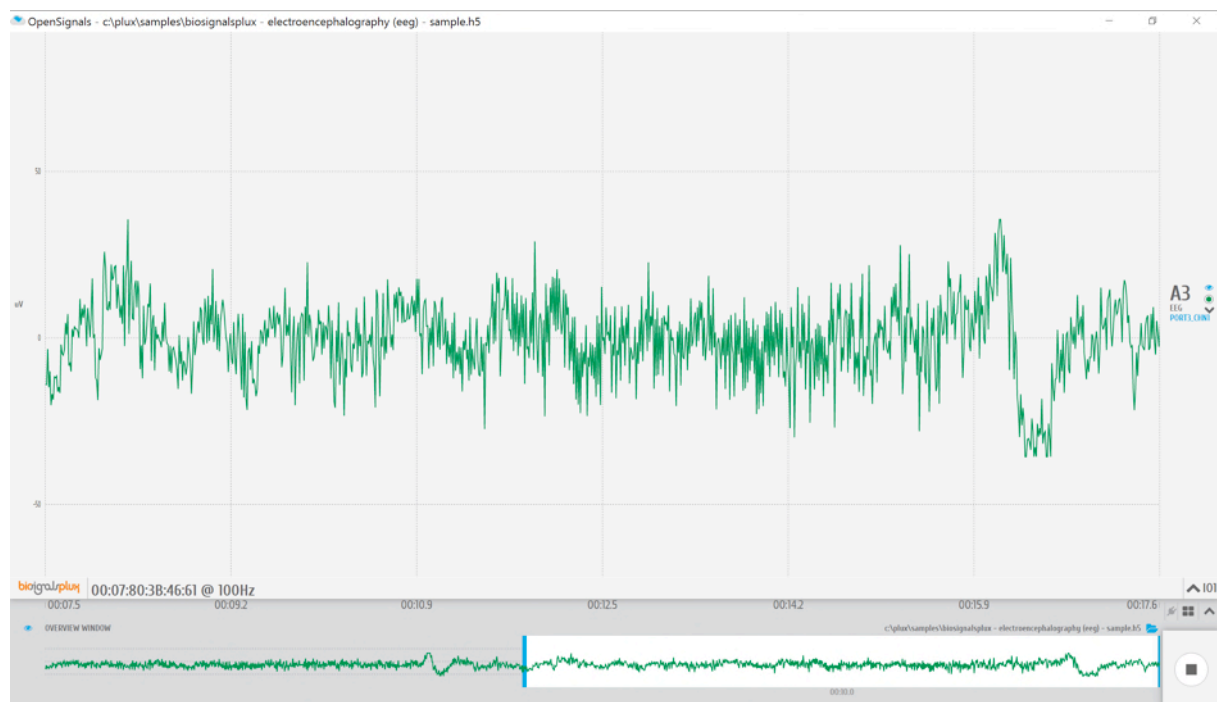


Figure 24: biosignalsplux EEG sensor sample.

### **Sensor specifications**

Please read the datasheet of the EEG sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/EEG\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/EEG_Sensor_Datasheet.pdf)

### 3.1.5 Accelerometer (ACC)

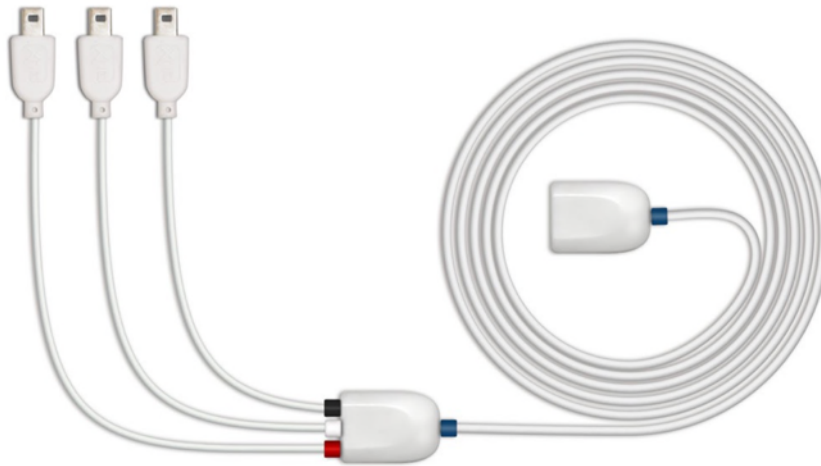


Figure 25: Accelerometer.

Our 3D accelerometer uses Micro Electro-Mechanical Systems (MEMS®) technology, and has been especially designed taking into account the requirements of applications where kinematics and motion measurements are required. Together with our biosignal acquisition hardware, this sensor can measure sub-milliG accelerations and provides the raw data of each axis as an independent quantity giving you full control.

#### **How to connect your sensor to your biosignalsplux**

The accelerometer can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*). This sensor requires up to 3 analog inputs of your *biosignalsplux* (1 for each axis).

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your accelerometer connected to. Select the channel(s) of your ACC sensor and select XYZ from the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel field). We recommend labelling your channels accordingly to your accelerometer configuration for better visualization purposes.

Activate each channel for signal acquisition by clicking on the circle in the channel field(s) (circle must be blue).

An example configuration is displayed in *Figure 26* (here: ACC connected to channel 1 to 3; channel 1 = x-axis; channel 2 = y-axis; channel 3 = z-axis).



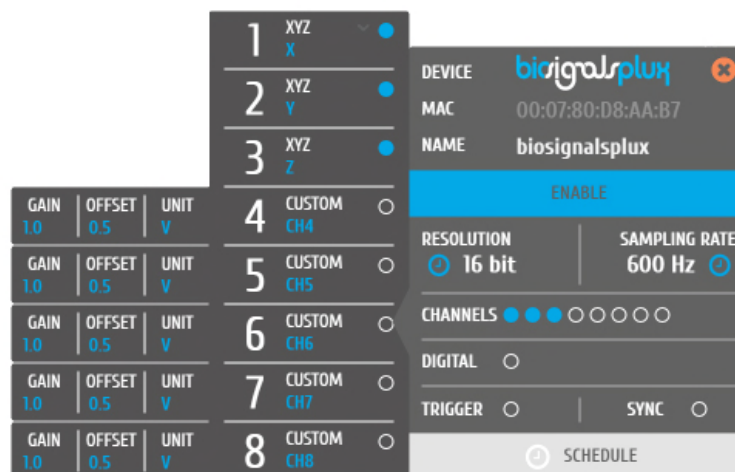


Figure 26: ACC configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in Figure 27.



Figure 27: biosignalsplux triaxial ACC sensor sample.

### Sensor specifications

Please read the datasheet of the accelerometer carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/ACC\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/ACC_Sensor_Datasheet.pdf)

### 3.1.6 Temperature (TMP)



Figure 28: Temperature sensor.

Our high performance NTC sensors have been specifically developed for biomedical applications and are meant to be used on a range of temperatures suitable for body sensing. These sensors produce a robust, stable, and accurate output with low tolerance values. The geometry and rapid response are also of added value for even the most demanding applications.

#### **How to connect your sensor to your biosignalsplux**

The temperature sensor can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*)

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your temperature sensor connected to. Select the channel of your temperature sensor and select *TEMP* out of the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field).

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 29* (here: temperature sensor connected to channel 1).

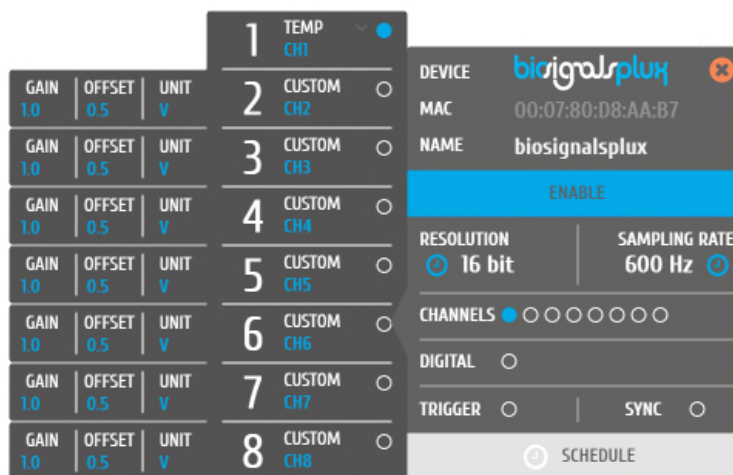


Figure 29: TMP configuration in OpenSignals.

If configured correctly, you should be able to acquire signals similar to the signal displayed in *Figure 30*.

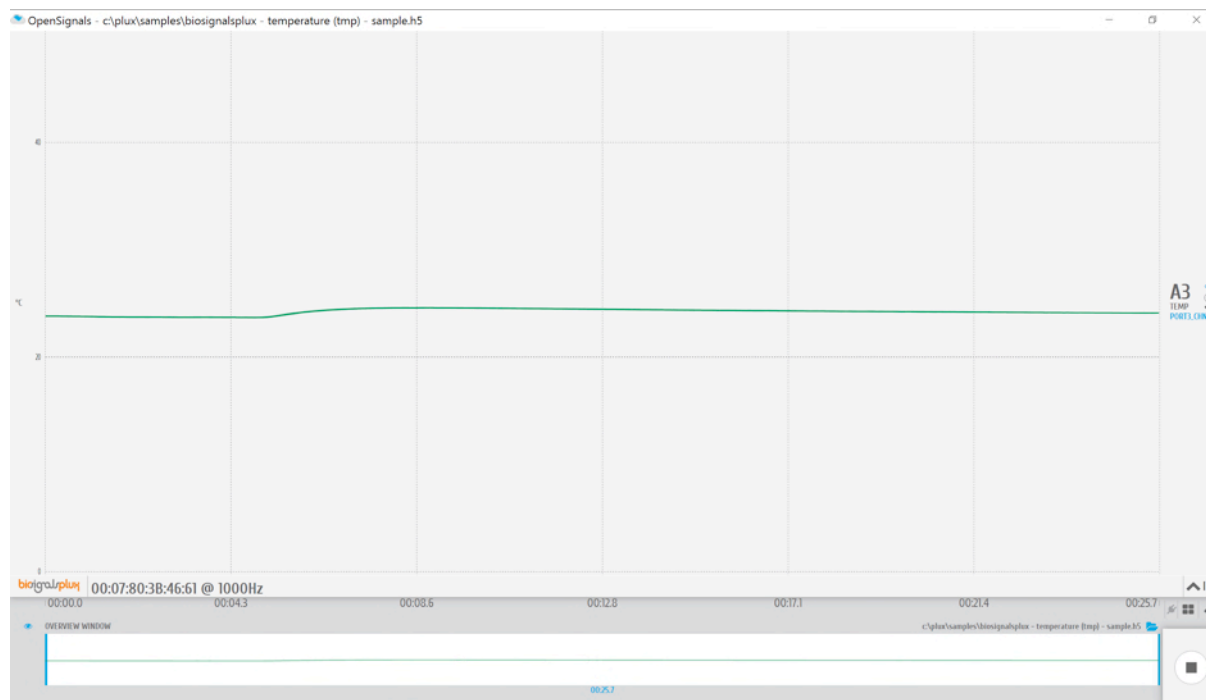


Figure 30: biosignalsplux temperature (TMP) sensor sample.

### 3.1.7 Respiration (PZT)



Figure 31: PZT sensor.

Our piezoelectric respiration sensor is an entry-level affordable option for respiratory analysis in a wide range of applications. It has a localized sensing element that measures displacement variations induced by inhaling or exhaling. The elastic strap is provided with the sensor to secure it in place, and can be adjusted in length, enabling the sensor to be applied in different anatomies (e.g. male and/or female) and body locations (e.g. thorax and/or abdomen).

#### How to use this sensor

This respiration sensor is a piezoelectric sensor and the membrane is centered on the flexible strip from where the cable comes out. As it measures respiration by means of the bending of the strip, the more the center of the strip is over the chest contour the better. Also, make sure the sensor fastened firmly to the chest to increase the signal quality and reliability. Signal quality will increase if the sensor is too loose.

#### How to connect your sensor to your biosignalsplux

The respiration sensor can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*).

This sensor does not require an additional reference electrode.

#### How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your respiration sensor connected to. Select the channel of your respiration sensor and select *RESP* from the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field).

Activate the respiration sensor's channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 32* (here: respiration sensor connected to channel 1).

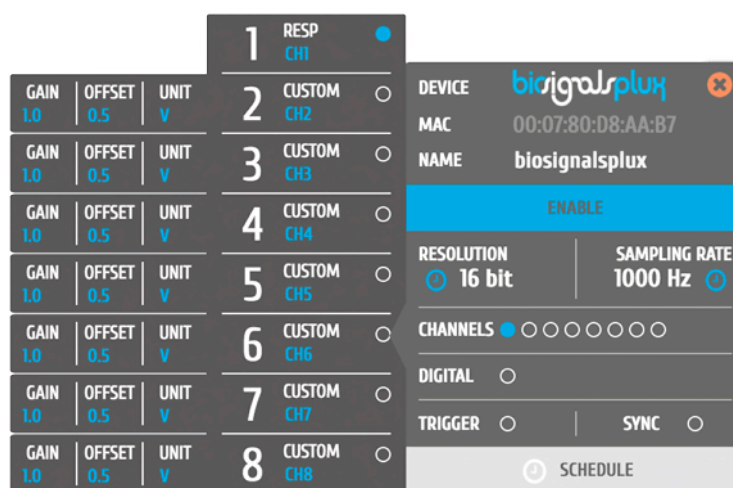


Figure 32: Respiration (PZT) configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in *Figure 33*.

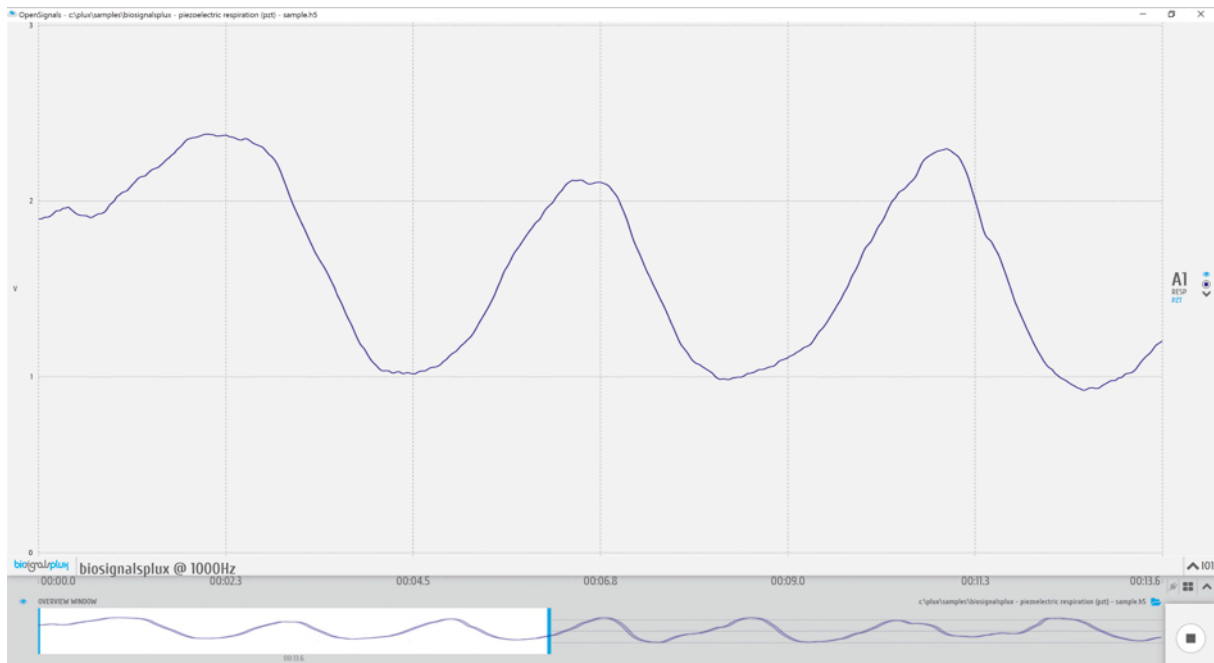


Figure 33: biosignalsplux respiration (PZT) sensor sample.

### OpenSignals (r)evolution Add-On: Respiration Analysis

The *Respiration Analysis* add-on add-on is a convenient way to determine respiratory rate and other useful temporal and statistical parameters associated with the respiratory

cycles and to provide useful information about the breathing dynamics. It is designed to work with sensor data acquired with this piezoelectric respiration sensor (PZT) (or with the inductive respiration sensor (RIP); see 3.2.1 *Respiration (RIP)* ).

This add-on is included in the *biosignalsplux Professional* kit (see 1.3 *biosignalsplux Professional*) and in the [raspiBAN PRO wearable](#) but it can also be bought additionally for the use with *biosignalsplux* hubs and wearables which can be used with this respiration sensor.

Please visit the following website for more information about this add-on:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### **Sensor specifications**

Please read the datasheet of the respiration sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/PZT\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/PZT_Sensor_Datasheet.pdf)

### 3.1.8 Force (FSR)

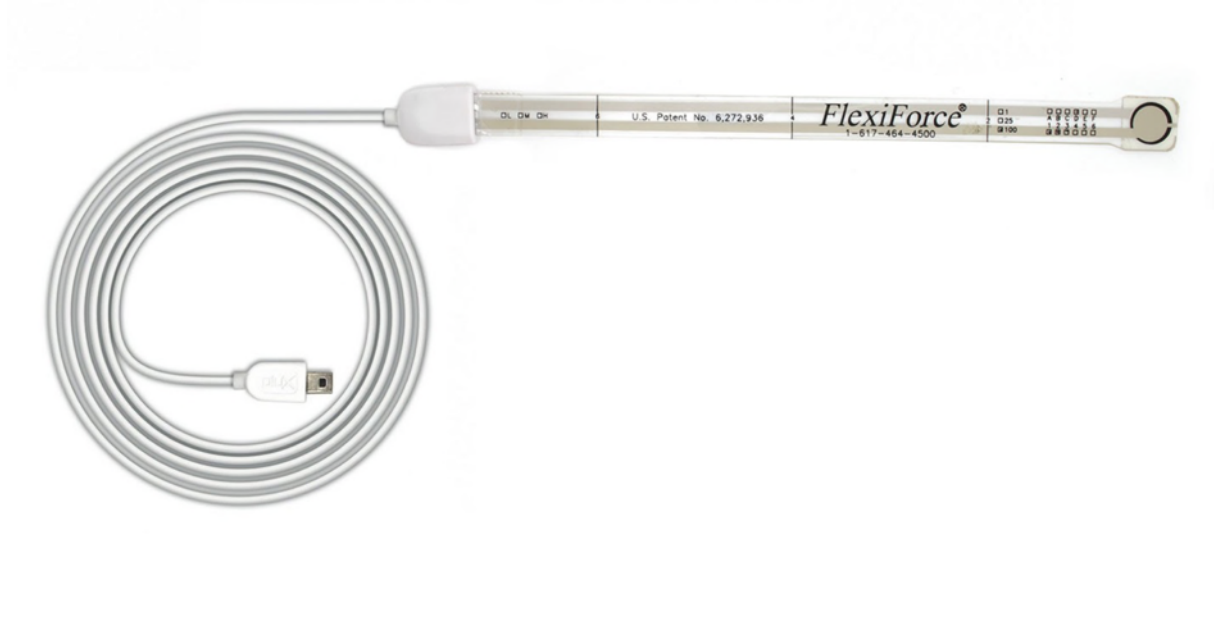


Figure 34: Force sensor.

From reaction time measurement to load distribution in shoe insoles, our thin film force sensors offer uncompromised performance in the most demanding applications. The low profile membrane and miniaturized signal conditioning circuitry are ideal for minimally intrusive setups. Multiple sensing area dimensions and measurement ranges are available.

#### How to connect your sensor to your biosignalsplux

ECG sensors can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*)

This sensor does not require an additional reference electrode.

#### How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your force sensor connected to. Select the channel of your force sensor and select *CUSTOM* from the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field). In the custom field of your channel, adjust the *GAIN* and *OFFSET* that fits best to your application. Testing and readjustments of this parameters might be needed to find the configuration that fits best your needs.

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 35* (here: force sensor connected to channel 1).

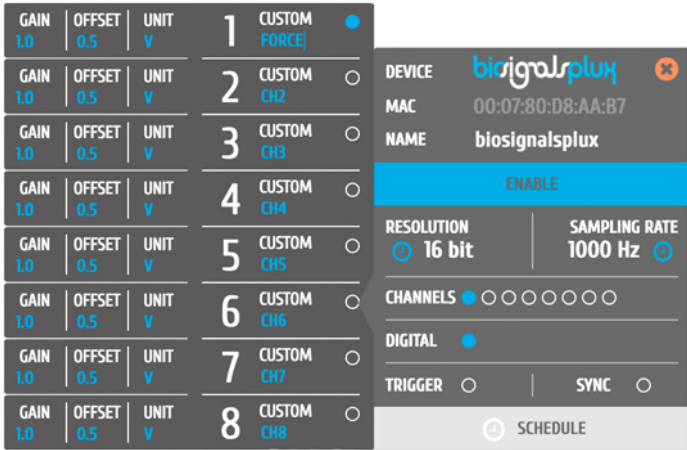


Figure 35: Force sensor configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in Figure 36.

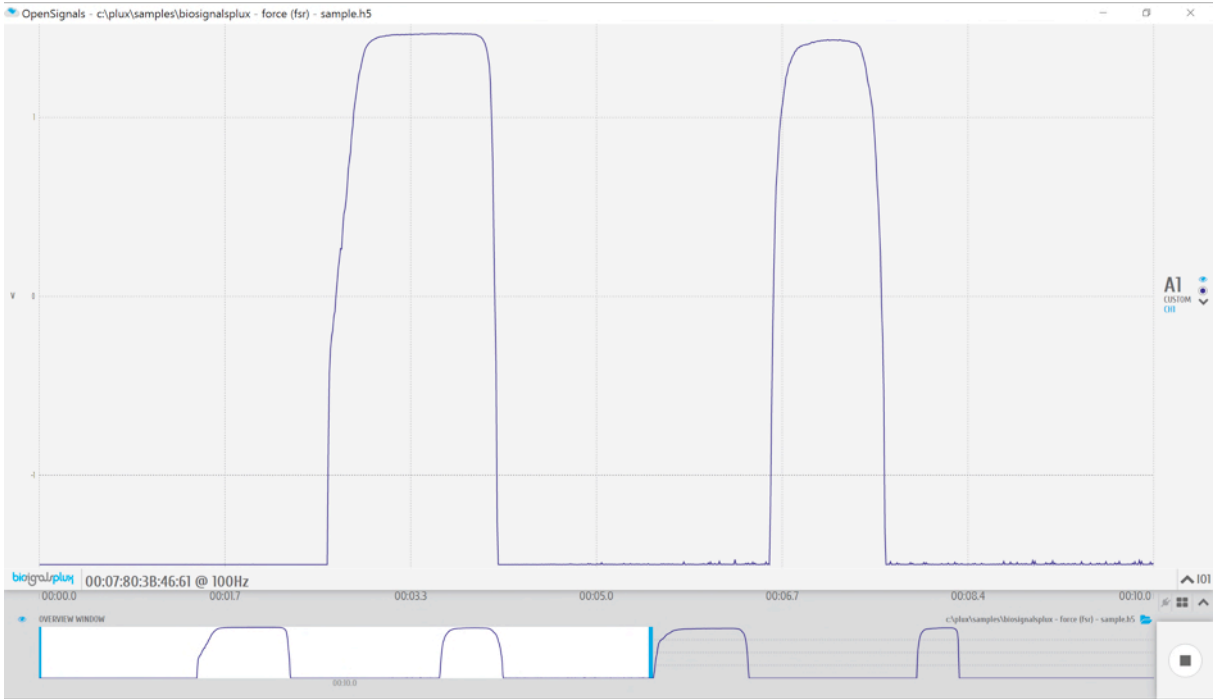


Figure 36: biosignalsplux force (FSR) sensor sample.



### 3.1.9 Light (LUX)



Figure 37: Light sensor.

A common need when working with biosignals is the synchronization of the recorded data with external sources (e.g. a computer screen for visual evoked potentials). If applied to the computer screen, our LUX sensor can be used to detect chromatic changes in the stimuli, hence providing a synchronization source. The LUX sensor can also be useful for optical synchronization with third-party devices (provided that the third-party device can trigger an LED), in applications where it is important to have electrical decoupling between devices.

#### **How to connect your sensor to your biosignalsplux**

The *biosignalsplux* light sensor can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*)

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Note, that the signal you are acquiring with this light sensor is affected by the ambient light and other light sources that are available at your experiment setup. Therefore, it is needed to adjust the acquired signal to fit to your application and setup.

For this, open the *OpenSignals (r)evolution* device manager and select the device you have your light sensor connected to. Select the channel of your light sensor and select *CUSTOM* from the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field). In the custom field of your channel, adjust the *GAIN* and *OFFSET* that fits best to your application. Testing and readjustments of this parameters might be needed to find the configuration that fits best your needs.

Activate the light sensor channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 38* (here: light sensor connected to channel 1).

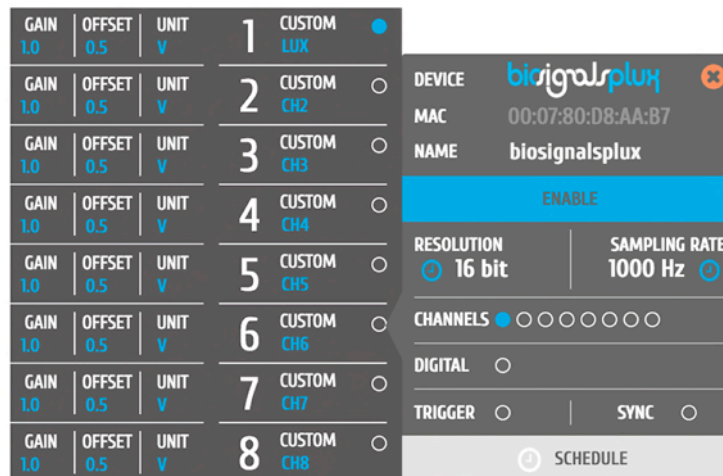


Figure 38: Light sensor configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in *Figure 39*.

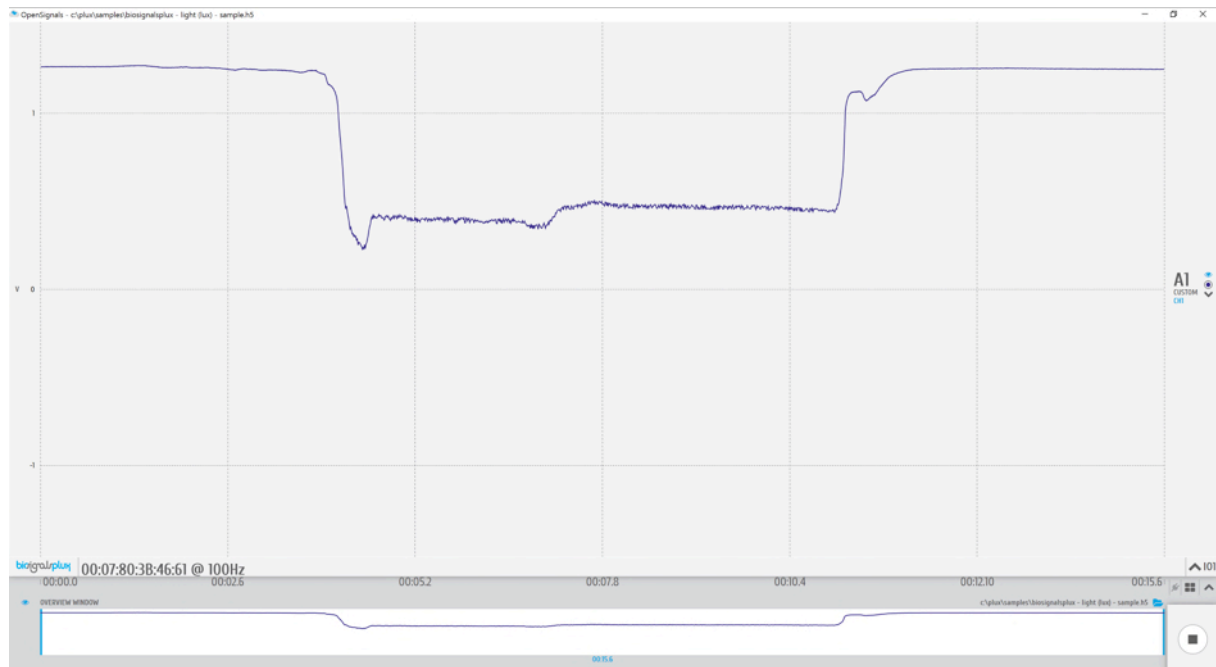


Figure 39: biosignalsplux light (LUX) sensor sample.

## OpenSignals (r)evolution Add-On: Video Synchronization

The *Video Synchronization* add-on has been designed for research applications which involve recording data from sources other than the biosignal acquisition hardware devices (e.g. video camera). Given that the biosignal hardware and the camera are

independent recording sources, a common problem when replaying the recording session is the synchronization of both. This plugin was created to provide an easy way to replay biosignal data synchronously with video using this light sensor (or the *biosignalsplux LED*; see 4.1.3 *Light-Emitting Diode (LED)* ).

This add-on is included in the *biosignalsplux Professional* kit (see 1.3 *biosignalsplux Professional*) and the *biosignalsplux Researcher* kit (see 1.2 *biosignalsplux Researcher*), and can also be bought additionally for the use with *biosignalsplux* hubs and wearables which can be used with this light sensor.

Please visit the following website for more information about this add-on:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### **Sensor specifications**

Please read the datasheet of the EMG sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/LUX\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/LUX_Sensor_Datasheet.pdf)

## 3.2 Advanced Sensors

### 3.2.1 Respiration (RIP)



Figure 40: Respiration (RIP) sensor.

This high-performance inductive respiration sensor has been specifically designed having dynamic conditions in mind (e.g. ambulatory sensing). The sensing element is embedded in the chest strap fabric, and spans its full length. Unlike our affordable piezoelectric (PZT) sensor (which only measures the displacement in a localized manner), the RIP option measures the overall displacement of the thorax or abdomen, making it more immune to motion-induced artefacts.

#### **How to connect your sensor to your biosignalsplux**

The respiration (RIP) sensor can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*).

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your respiration sensor connected to. Select the channel of your respiration sensor and select *RESP* from the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field).

Activate the respiration sensor's channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 41* (here: respiration sensor connected to channel 1).

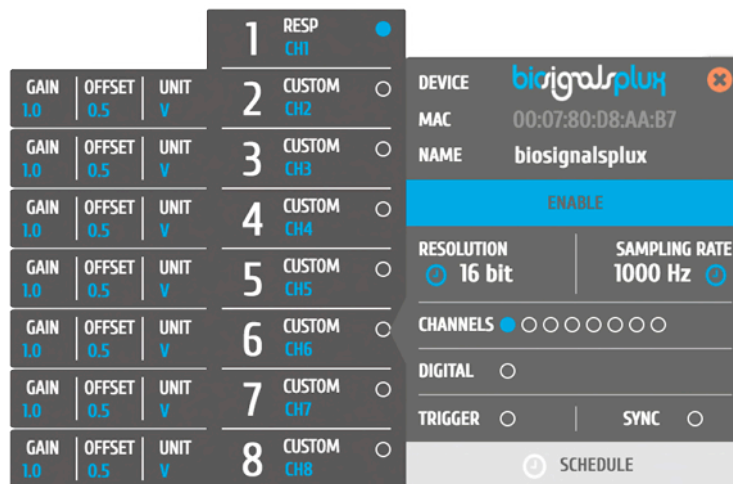


Figure 41: Respiration (RIP) configuration in OpenSignals.

### OpenSignals (r)evolution Add-On: Respiration Analysis

The *Respiration Analysis* add-on is a convenient way to determine respiratory rate and other useful temporal and statistical parameters associated with the respiratory cycles and to provide useful information about the breathing dynamics. It is designed to work with sensor data acquired with this inductive respiration sensor (RIP) (or with the piezoelectric respiration sensor (PZT); see 3.1.7 *Respiration (PZT)* ).

This add-on is included in the *biosignalsplux Professional* kit (see 1.3 *biosignalsplux Professional*) and in the [raspiBAN PRO wearable](#) but it can also be bought additionally for the use with *biosignalsplux* hubs and wearables which can be used with this respiration sensor.

Please visit the following website for more information about this add-on:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### Sensor specifications

Please read the datasheet of the respiration sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/RIP\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/RIP_Sensor_Datasheet.pdf)

### 3.2.2 Goniometer (GON)

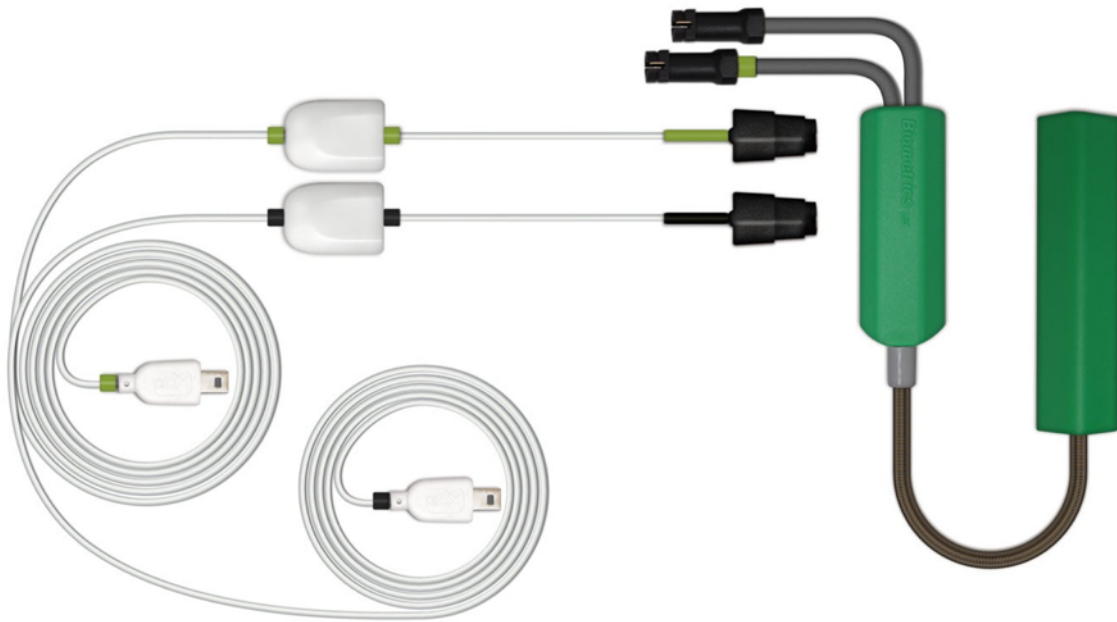


Figure 42: Goniometer.

This twin-axis goniometer provides accurate data related with flexion/extension and ulnar/radial deviation. With two attachment points to the body and a flexible beam, it enables high-performance uncompromised operation even in dynamic scenarios, without limiting the motion of the monitored subjects. Multiple size options are available, enabling placement in segments ranging from a finger (e.g. intermediate – proximal phalanges) to a leg (e.g. lower part of the femur – upper part of the tibia).

#### **How to connect your sensor to your biosignalsplux**

The goniometer can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*) This sensor requires 2 analog inputs of your *biosignalsplux*.

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your goniometer connected to. Select the channels of your goniometer and select *GONIO* for both channels from of the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field).

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 43* (here: goniometer connected to channel 1).

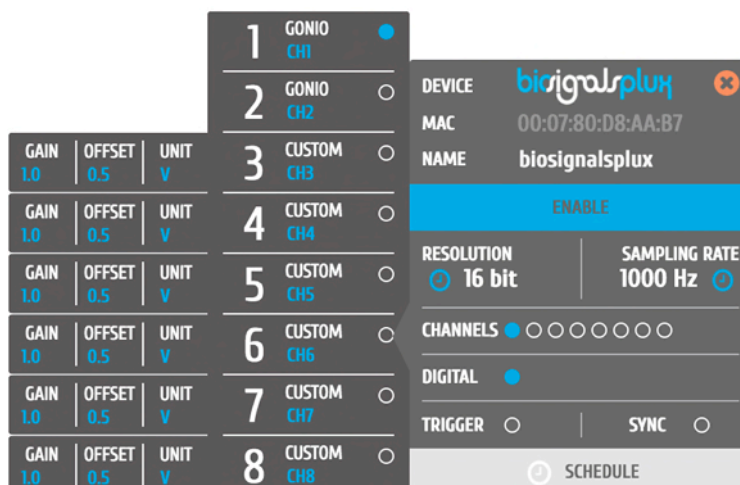


Figure 43: Goniometer configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in Figure 44.

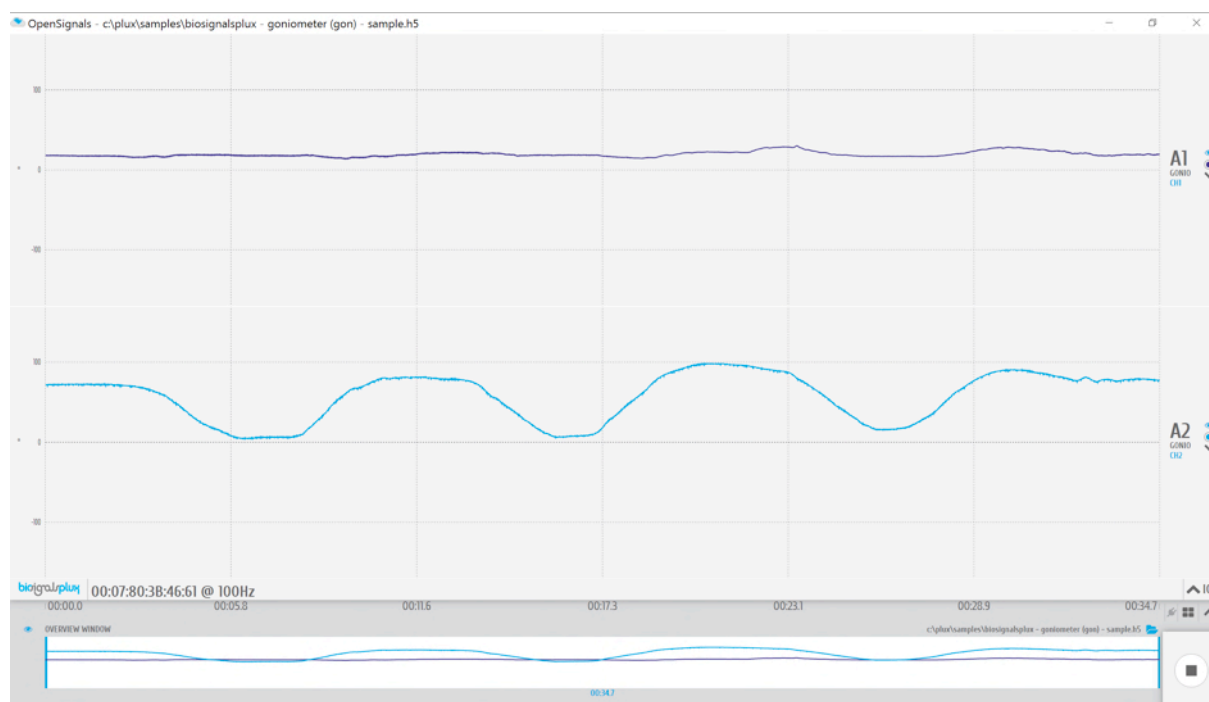


Figure 44: biosignalsplux goniometer sensor sample.

## Sensor specifications

Please read the datasheet of the goniometer carefully before using it the first time. The datasheet can be found at the end of this manual or using the following link:

[http://biosignalsplux.com/datasheets/GON\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/GON_Sensor_Datasheet.pdf)

### 3.2.3 Load Cell

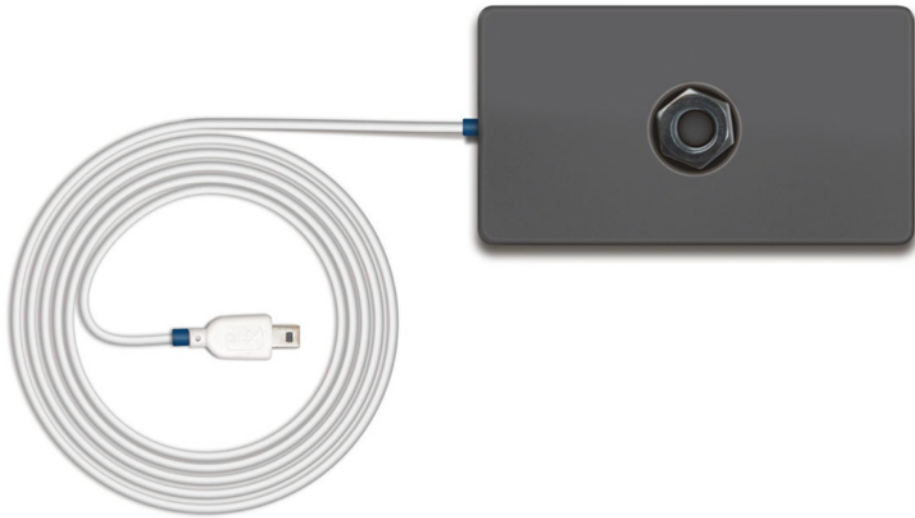


Figure 45: Load cell.

This single-axis load cell is particularly suitable for handgrip, traction/compression, and similar applications. Its sturdy design and accessories enable force measurement in many different settings. The plug & play design provides maximum flexibility for use with our biosignal acquisition kits.

#### **How to connect your sensor to your biosignalsplux**

The load cell can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*).

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your load cell connected to. Select the channel of your load cell and select *HANDGR* from the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field).

Activate the respiration sensor's channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 46* (here: load cell connected to channel 1).



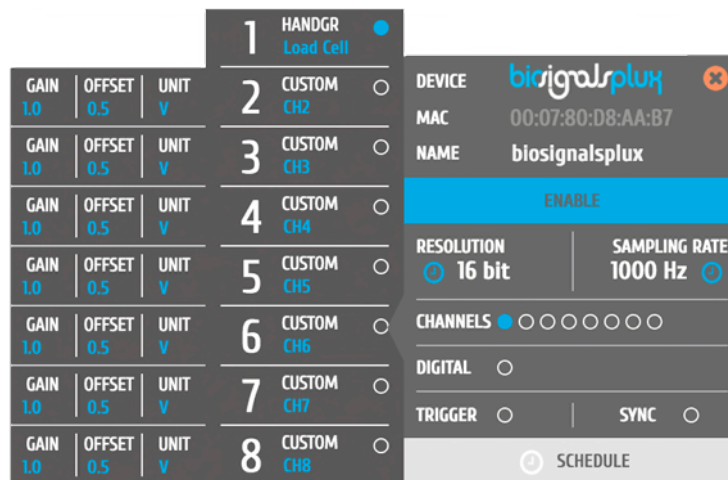


Figure 46: Load cell configuration in OpenSignals.

### OpenSignals (r)evolution Add-On: Center of Mass Analysis

The *Center of Mass Analysis* add-on can be used for several applications using 4 of these sensors with the *biosignalsplux Force Platform* (see 1.4 *biosignalsplux Force*). Center of gravity distribution, jump analysis, weight assessment and force production capacity are just some of applications. This plugin allows you to observe, in real-time, the center of gravity and the force produced in each moment.

This add-on is included in the *biosignalsplux Force* kit (see 1.4 *biosignalsplux Force*).

Please visit the following website for more information about this add-on:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### Sensor specifications

Please read the datasheet of the load cell carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/Load\\_Cell\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/Load_Cell_Datasheet.pdf)

### 3.2.4 Vaginal Probe (Pelvic EMG Sensor)

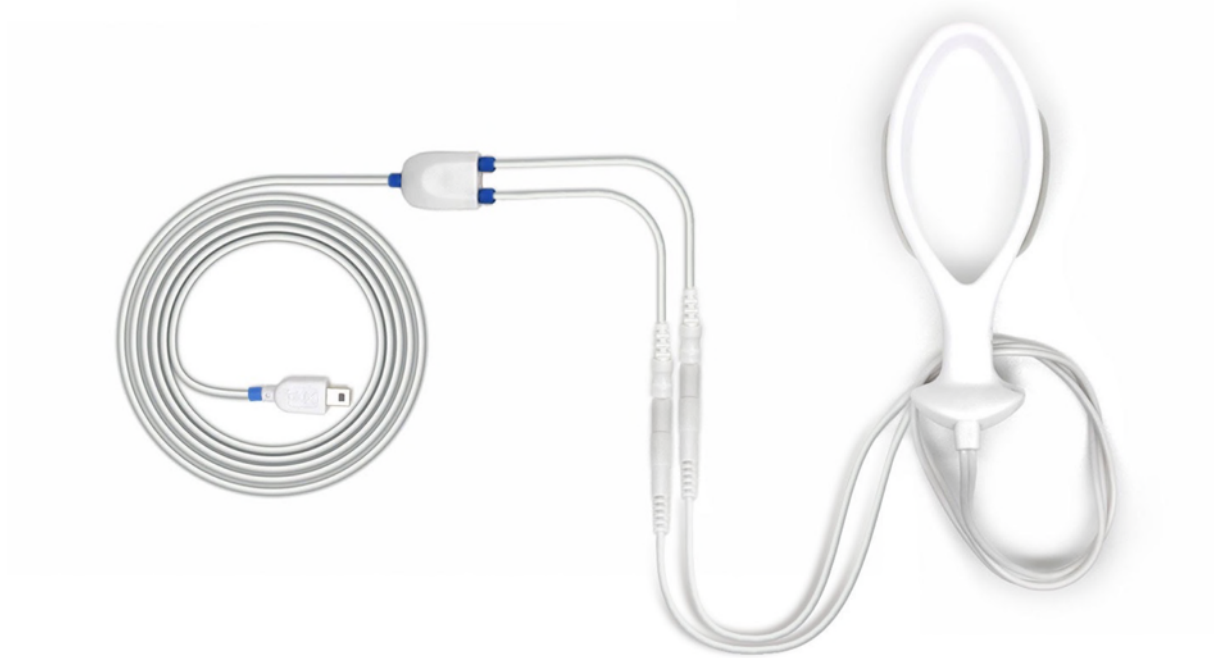


Figure 47: Vaginal probe.

This sensor is especially designed for high performance pelvic floor EMG data acquisition. 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 electrophysiology research.

#### **How to connect your sensor to your biosignalsplux**

The vaginal probe for applications measuring pelvic EMG can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*)

This EMG sensor has no built-in reference electrode. We recommend connecting a reference electrode the reference input of your device (see 2.3.3 *Reference*) which can then be used as reference signal for your EMG signal(s). For optimal signal acquisition, place your ground electrode on a region of the body with low level of muscle activity.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your EMG sensor connected to. Select the channel of your EMG sensor and select *EMG* out of the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field). No additional set up is needed for the reference electrode inside *OpenSignals (r)evolution*.

Activate this sensor's channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed *Figure 48* (here: vaginal probe connected to channel 1).

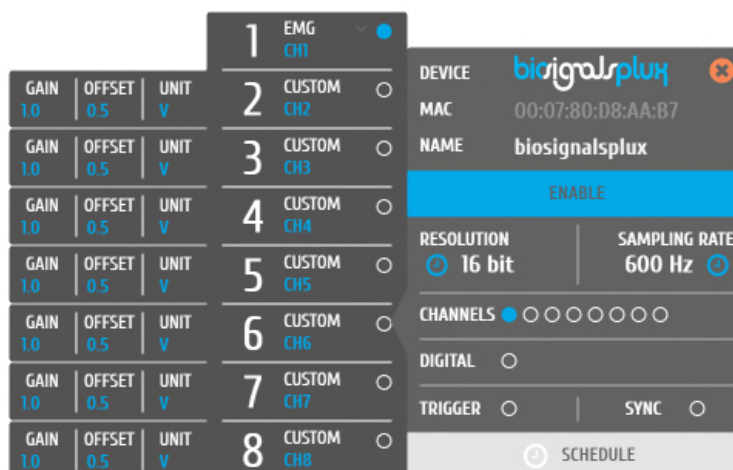


Figure 48: Vaginal probe configuration in OpenSignals.

### Sensor specifications

Please read the datasheet of the EMG sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/EMG\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/EMG_Sensor_Datasheet.pdf)

### 3.2.5 RFID Sensor

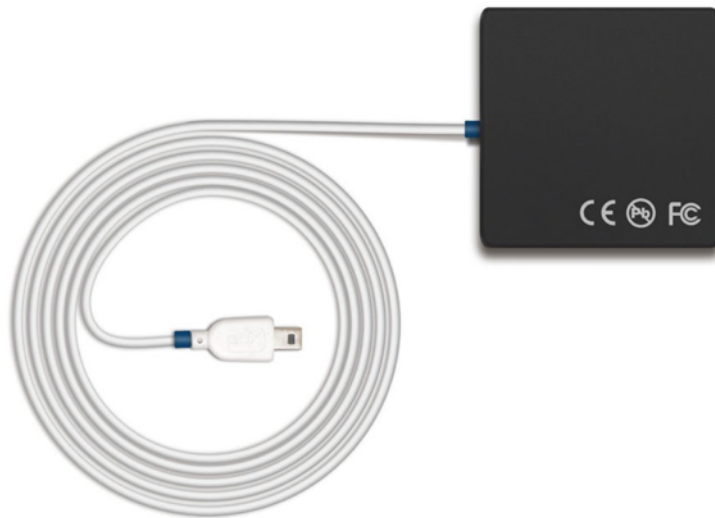


Figure 49: RFID sensor.

This sensor is useful for synchronous recording of biosignal data and ID-mappable events. Usage examples include token detection and reaction time analysis in object manipulation tasks, and also differentiated event annotation.

#### **How to connect your sensor to your biosignalsplux**

The RFID sensor can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 Analog Inputs).

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your RFID sensor connected to. Select the channel of your RFID sensor and select *CUSTOM* from the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field). In the custom field of your channel, adjust the *GAIN* and *OFFSET* that fits best to your application. Testing and readjustments of this parameters might be needed to find the configuration that fits best your needs.

Alternatively, you can also use the *RAW* option, which will display the raw digital signals that are received from the *biosignalsplux*.

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 50* (here: RFID sensor connected to channel 1).

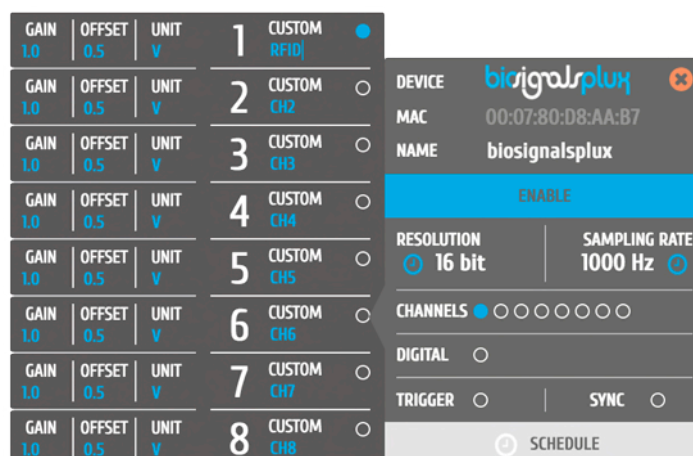


Figure 50: Load cell configuration in OpenSignals.

### Sensor specifications

Please read the datasheet of the RFID sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/RFID\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/RFID_Sensor_Datasheet.pdf)

### 3.2.6 Blood Volume Pulse (BVP)

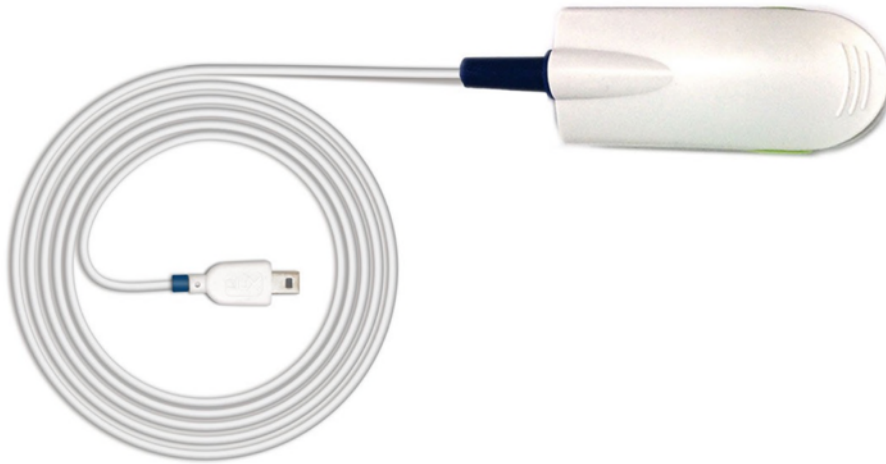


Figure 51: BVP sensor.

This Blood Volume Pulse (BVP) sensor is an optical, non-invasive sensor that measures cardiovascular dynamics by detecting changes in the arterial translucency. When the heart pumps blood the arteries become more opaque, allowing less light to pass from the emitter on the sensor through to the receiver. The BVP sensor has a plastic clip-on housing for placement on the finger, which houses the light emitter and detector, and also minimizes interferences from external light sources.

#### **How to connect your sensor to your biosignalsplux**

The blood volume pulse sensor can be connected to any of the available analog inputs of your *biosignalsplux* device (see 2.3.2 *Analog Inputs*)

This sensor does not require an additional reference electrode.

#### **How to configure your sensor in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select the device you have your blood volume pulse sensor connected to. Select the channels of your sensor and select *BVP* for the channel from of the dropdown menu (click on the arrow in the channel's field that appears when you hover over the channel's field).

Activate this channel for signal acquisition by clicking on the circle in the channel field (must be blue).

An example configuration is displayed in *Figure 52* (here: blood volume pulse sensor connected to channel 1).

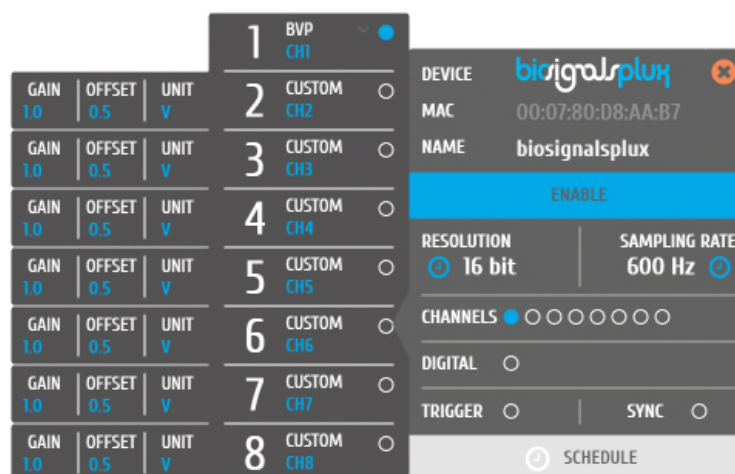


Figure 52: Blood volume pulse sensor configuration in OpenSignals.

If configured correctly, your acquired signals should be similar to the signal displayed in Figure 53.

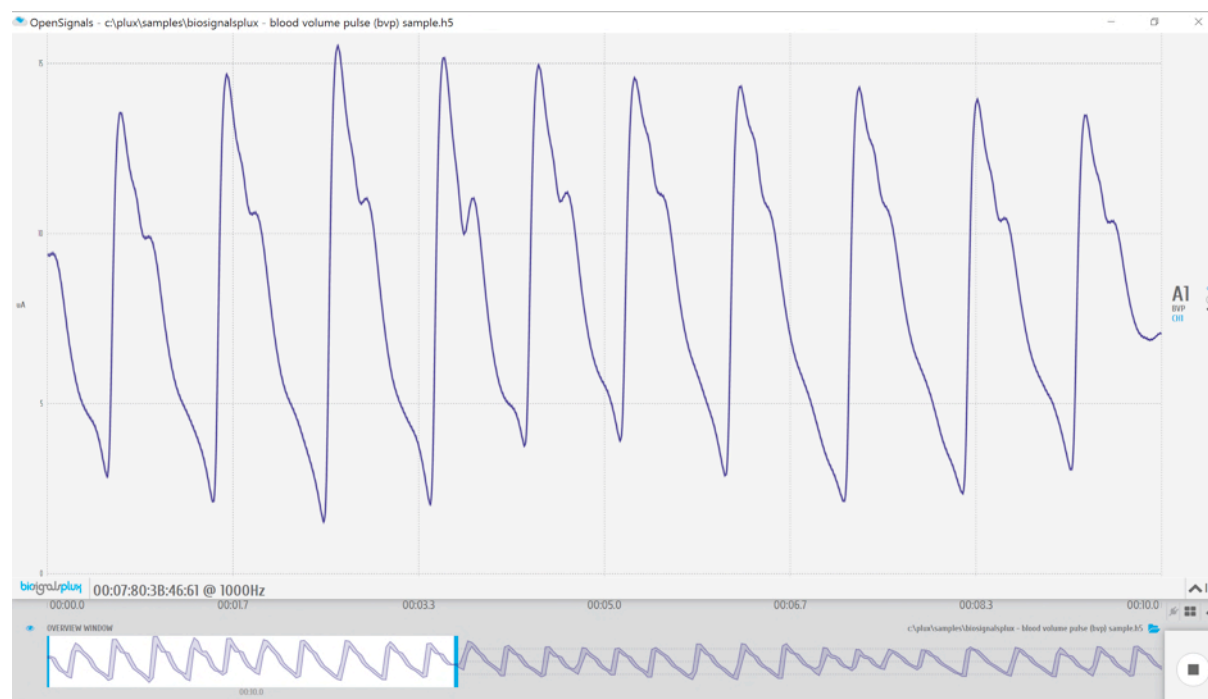


Figure 53: biosignalsplux blood volume pulse (BVP) sensor sample.

### OpenSignals (r)evolution Add-On: Heart Rate Variability

The *Heart Rate Variability* add-on provides important quantitative markers related with the sympathetic or vagal activity. This plugin enables the seamless extraction and analysis of temporal, spectral, and non-linear parameters from sensor data acquired with this BVP sensor (or the ECG sensor; see 3.1.2 *Electrocardiography* (ECG)).

This add-on is included in the *biosignalsplux Professional* kit (see 1.3 *biosignalsplux Professional*) and in the [cardioBAN wearable](#) but it can also be bought additionally for the

use with *biosignalsplux* hubs and wearables which can be used with this BVP sensor. Please visit the following website for more information:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### **Sensor specifications**

Please read the datasheet of the blood volume pulse sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/BVP\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/BVP_Sensor_Datasheet.pdf)



### 3.2.7 SpO2



*Figure 54: SpO sensor (versatile).*



*Figure 55: SpO2 sensor with finger clip.*

The SpO2 (peripheral capillary oxygen saturation) sensor uses two emitting LED's one in the red region and the other in the infrared region of the spectrum. The reflected light of each one of these LED's is absorbed by a photodiode that converts this current into a digital value that is sent via SPI. This sensor can be used to estimate the oxygen saturation level on the blood with +/- 2% accuracy compared to a medical sensor.

## Firmware requirements

The fNIRS sensor requires a specific *biosignalsplux* firmware version (v.3.4) to work. Please follow the instructions in chapter 8 *Firmware Updates & Upgrades* to learn how to check the current firmware version of your device and to upgrade or downgrade the firmware to version 3.4. if another version is currently being used on your device.

You can download the correct firmware here (v.3.4 for SpO2 & fNIRS):

<http://biosignalsplux.com/en/software/utilities>

After checking and, if required, downgrading or upgrading your device's firmware, remove your device from the *OpenSignals (r)evolution* device manager and your computer's Bluetooth list and reconnect your device inside *OpenSignals (r)evolution*. If the firmware change has been successfully, your device should now be displayed with an orange *biosignalsplux* in your device manager (see Figure 56).

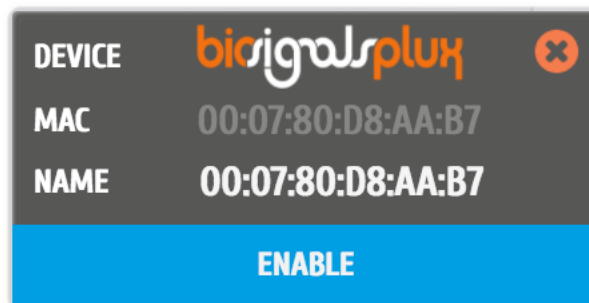


Figure 56: biosignalsplux device panel with firmware 3.4.

## How to connect your sensor to your biosignalsplux

The SpO2 sensor(s) have to be connected to the ground port of your device. Connecting this sensor to an analog input of your device will not work.

## How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your SpO2 sensor connected to.

In the device's panel, set up channel 9 for signal acquisition, set the port (P) to 9 and the channel (C) to 1 and select one of the available SpO2 options in the channel's dropdown menu. The different options are designed for different placement areas of the SpO2 sensor. We recommend selecting the available configuration that fits best your needs. The following configurations are available:

- *SPO2.ARM* for applications where the sensor is placed on the subject's arm
- *SPO2.FING* for applications where the sensor is placed on the subject's finger
- *SPO2.HEAD* for applications where the sensor is placed on the subject's head

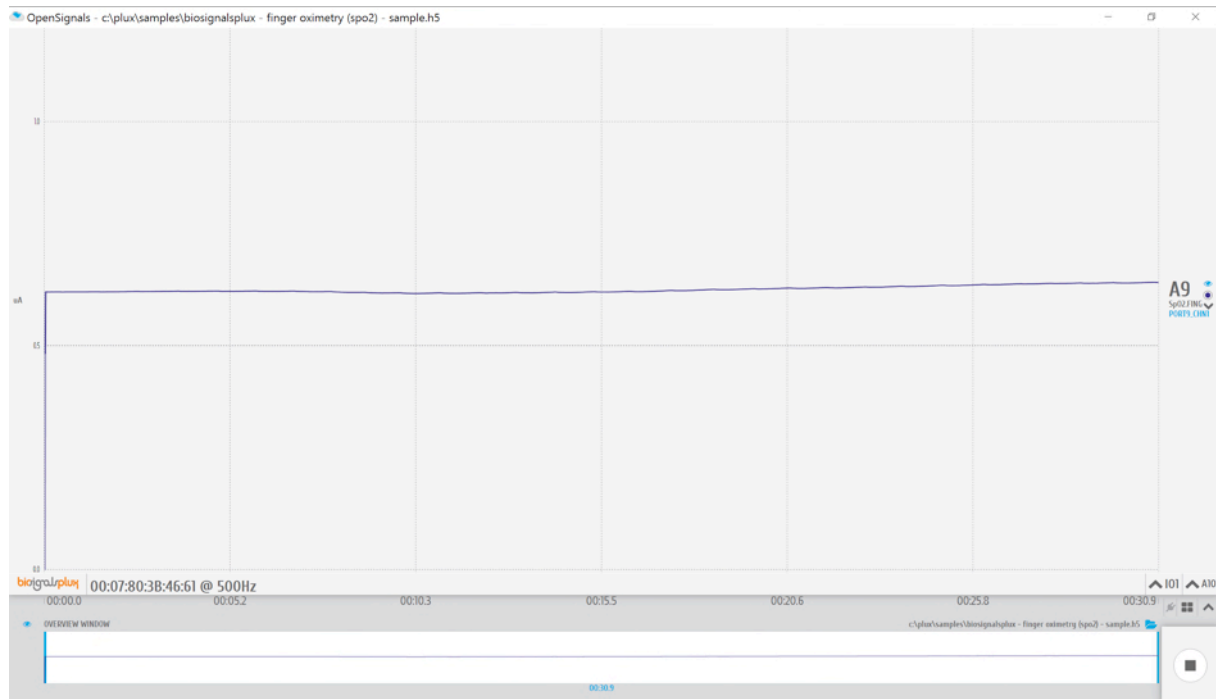


Figure 57: biosignalsplux SpO2sensor sample.

### Sensor specifications

Please read the datasheet of the SpO2 sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://www.biosignalsplux.com/datasheets/SpO2\\_Sensor\\_Datasheet.pdf](http://www.biosignalsplux.com/datasheets/SpO2_Sensor_Datasheet.pdf)

### 3.2.8 fNIRS



Figure 58: biosignalsplux fNIRS sensor.

The fNIRS (functional near-infrared spectroscopy) sensor measures the red and infrared light reflectance in the cortical tissue. This sensor is typically applied on the forehead and it can be used to estimate the blood oxygen saturation level in the brain tissue. Possible applications include brain activity monitoring, functional neuroimaging and advanced BCI systems.

#### Firmware requirements

The fNIRS sensor requires a specific *biosignalsplux* firmware version (v.3.4) to work. Please follow the instructions in chapter 8 *Firmware Updates & Upgrades* to check the current firmware version of your device and to upgrade or downgrade the firmware to version 3.4. if another version is currently being used on your device.

You can download the correct firmware here (v.3.4 for SpO2 & fNIRS):

<http://biosignalsplux.com/en/software/utilities>

After checking and, if required, downgrading or upgrading your device's firmware, remove your device from the *OpenSignals (r)evolution* device manager and your computer's Bluetooth list and reconnect your device inside *OpenSignals (r)evolution*. If the firmware change has been successfully, your device should now be displayed with an orange *biosignalsplux* in your device manager (see Figure 59).



Figure 59: biosignalsplux device panel with firmware 3.4.

### How to connect your sensor to your biosignalsplux

The fNIRS sensor needs to be connected to the ground port of your device. Connecting this sensor to an analog input of your device will not work.

### How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your fNIRS sensor connected to.

In the device's panel, set up the channels 9 and 10 for signal acquisition and set the sensor type to *fSpO2* or, if not available, to *SpO2.HEAD* (click on the arrow in the channel's field that appears when you hover over the channel's field). For channel 9, set the port (P) to 9 and the channel (C) to 1. For channel 10, set the port (P) to 9 and the channel to (C) 2.

Channel 9 visualizes the reflected light of the red LED, while channel 10 visualizes the reflected light of the IR. The intensities of the LEDs can be configured individually by changing the sliders at the left side next to the channel configuration panels. If configured correctly, the device panel should be similar to Figure 60.



Figure 60: Configuration of the fNIRS sensor with biosignalsplux.

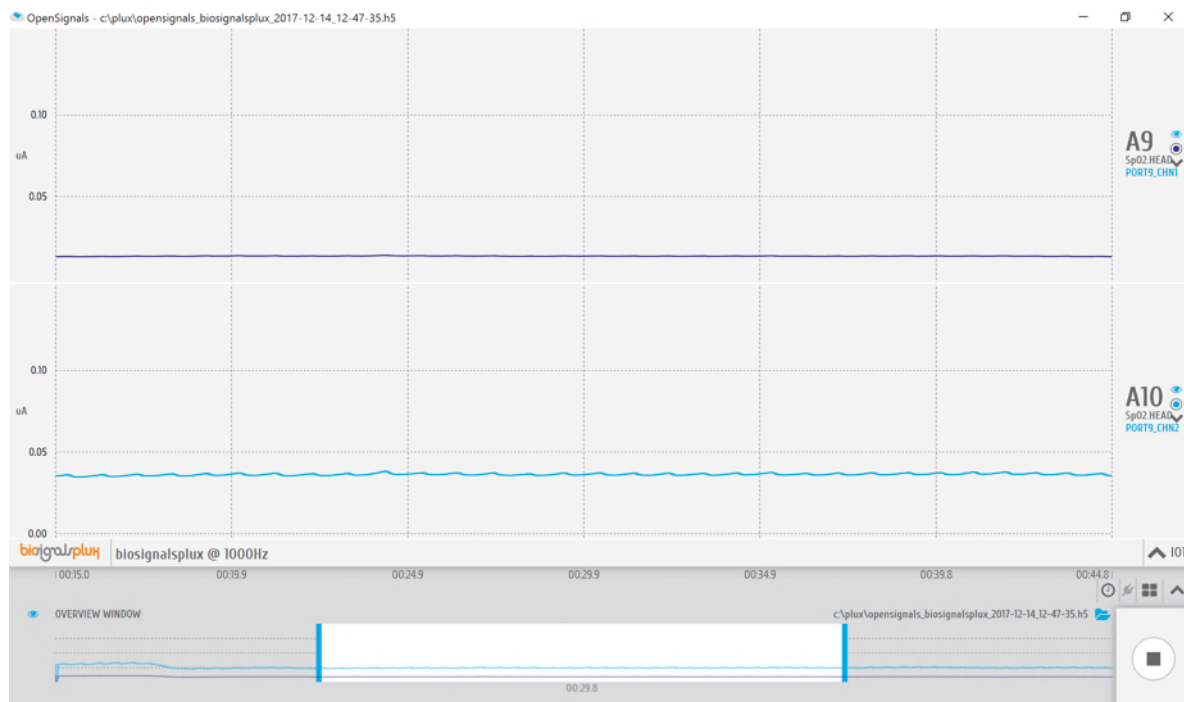


Figure 61: biosignalsplux SpO2sensor sample.

### Sensor specifications

Please read the datasheet of the fNIRS sensor carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/fNIR\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/fNIR_Sensor_Datasheet.pdf)

### 3.2.9 Blood Pressure Reader (BPR)

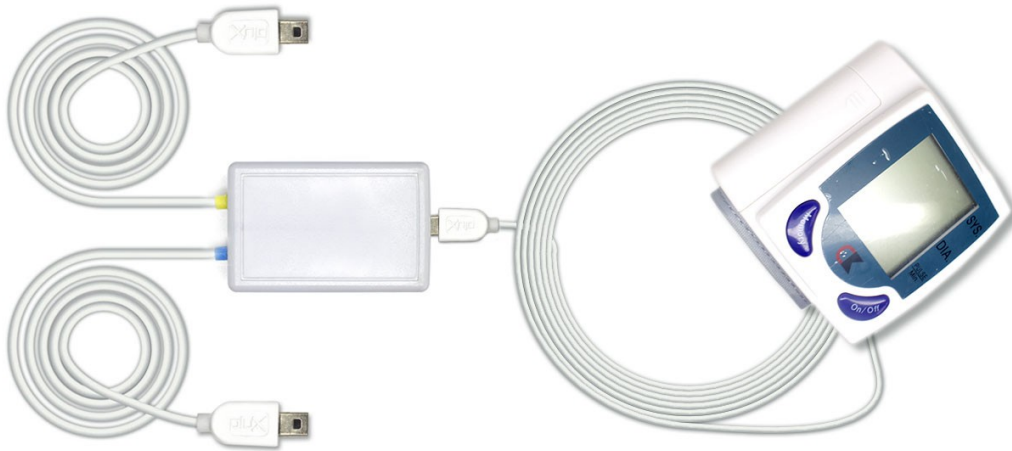


Figure 62: Blood pressure reader.

This user-friendly upper arm cuff-based blood pressure monitor measures systolic & diastolic blood pressure levels (in mmHg) with  $\pm 3$ mmHg accuracy. The built-in colour LCD display displays all measured blood pressure values and additional heart rate information (bpm) and allows this sensor to be used both as standalone device or as *biosignalsplux* sensor within our [OpenSignals \(r\)evolution software](#).

#### NOTE

This sensor is an adaptation of the 3rd party CK101 Wrist Blood Pressure Monitor which provides compatibility with biosignalsplux devices. It can be used both as standalone device or as *biosignalsplux* sensor.

Please do also read the datasheet of the standalone device before using this sensor:  
[http://biosignalsplux.com/datasheets/telemedicine/Goodwill\\_Studio\\_Ver1.pdf](http://biosignalsplux.com/datasheets/telemedicine/Goodwill_Studio_Ver1.pdf)

#### How to connect your sensor to your biosignalsplux

Connect the BPR sensor to the adapter box. When done, connect the outgoing cables to any available analog inputs of your *biosignalsplux* (see 2.3.2 *Analog Inputs*). Note that this sensor has individual channels for the diastolic and systolic signals.

#### How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your BPR sensor connected to. Select the channel of your diastolic signal channel and set the



sensor type to *DIA* (click on the arrow in the channel's field that appears when you hover over the channel's field and select *DIA* from the dropdown menu). Select the channel of your systolic signal channel and set the sensor type to *SYS*<sup>5</sup>.

Activate both channels for signal acquisition by clicking on the circle in the channel field (must be blue).

### How to use your sensor

This sensor is designed to measure blood pressure levels at the wrist. Place the sensor at the wrist of the user (ideally the left wrist) such that both the sensor's display and the hand palm are facing towards the user. Please do also check the instructions provided on the cuff to ensure optimal acquisition results.

Signal acquisitions in *OpenSignals (r)evolution* are done by initializing the signal acquisition in *OpenSignals* and pressing the *On/off* button on your sensor. The cuff will start to fill itself with air and the sensor will conduct the blood pressure measurement.

If configured correctly, your acquired signals should be similar to the signal displayed in Figure 63. Note that the sensor will achieve different states during the measurement which can be seen in the acquires signal:

- A. Sensor is not turned on but not conducting a measurement
- B. Sensor cuff is being filled with air; ongoing blood pressure measurement
- C. Sensor results for diastolic and systolic blood pressure values

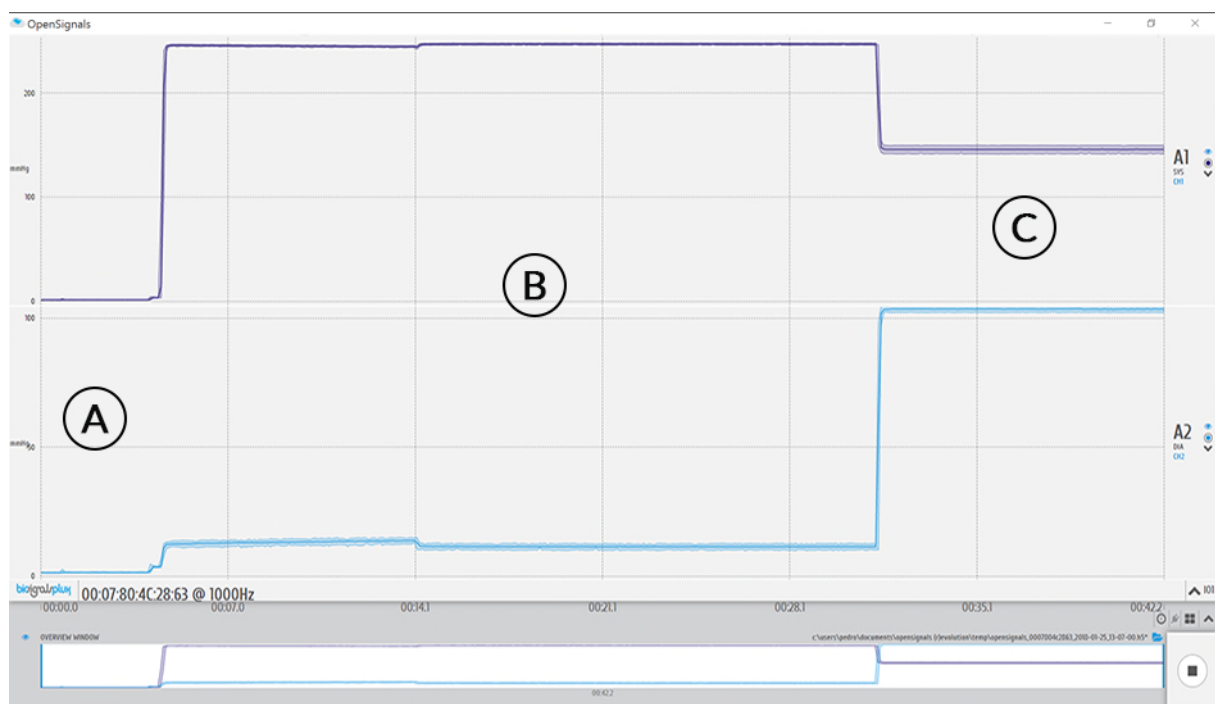


Figure 63: Blood pressure reader sample.

<sup>5</sup> The sensor types *SYS* (systolic) and *DIA* (diastolic) are only supported by *OpenSignals (r)evolution* versions of 30.01.2018 or newer.



### 3.2.10 SpO2 Reader (OSL)



Figure 64: SpO2 reader.

This comfortable and user-friendly finger clip sensor was designed to measure reliable oxygen saturation levels (%) and heart rate (bpm) information. The built-in colour LCD display displays all measured values and signals and allows this sensor to be used both as standalone device or as *biosignalsplux* sensor within our [OpenSignals \(r\)evolution software](#).

#### NOTE

This sensor is an adaptation of the 3rd party *CMS-50D Plus* which provides compatibility with *biosignalsplux* devices. It can be used both as standalone device or as *biosignalsplux* sensor.

Please do also read the datasheet of the standalone device before using this sensor:  
[http://biosignalsplux.com/datasheets/telemedicine/CMS-50D\\_Plus.pdf](http://biosignalsplux.com/datasheets/telemedicine/CMS-50D_Plus.pdf)

#### How to connect your sensor to your biosignalsplux

Connect the sensor to the adapter box using the micro-USB cable which comes pre-connected to the adapter box. When done, connect the outgoing cables to any of the available analog inputs of your *biosignalsplux* (see [2.3.2 Analog Inputs](#)). Note that this sensor has individual channels for the SpO2 and heart rate signals.

#### How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your OSL sensor connected to. Select the channel of your SpO2 signal and set the sensor type

to *OXI* (click on the arrow in the channel's field that appears when you hover over the channel's field and select *OXI* from the dropdown menu). Select the channel of your heart rate signal channel and set the sensor type to *HR*<sup>6</sup>.

Activate both channels for signal acquisition by clicking on the circle in the channel field (must be blue).

### How to use your sensor

This sensor is designed to measure oxygen saturation levels and heart rate on the index finger.

To start acquiring a signal with this sensor when using *OpenSignals (r)evolution*, start the signal acquisition in *OpenSignals* and hold the *On/off* button at the top side of your sensor until the display is turned on. The sensor data will no be visible in *OpenSignals (r)evolution*.

If configured correctly, your acquired signals should be similar to the signal displayed in *Figure 65*.

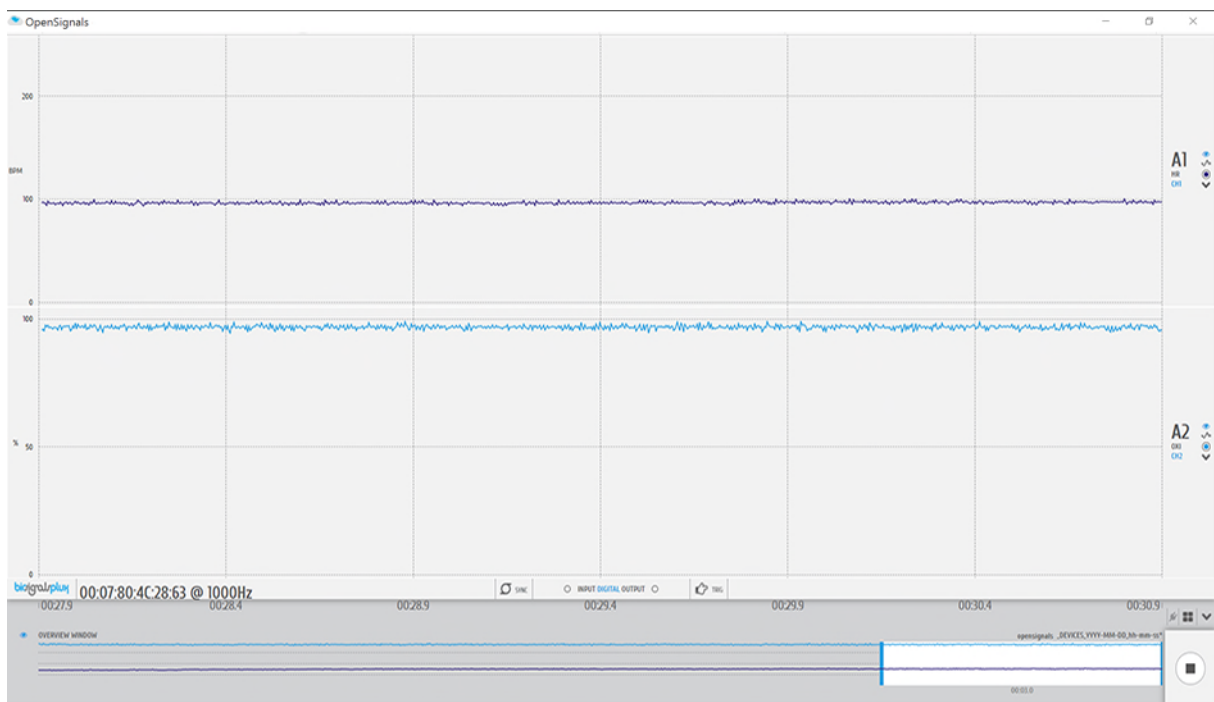


Figure 65: SpO2 reader sample.

<sup>6</sup> The sensor types *OXI* (oxygen saturation level) and *HR* (heart rate) are only supported by *OpenSignals (r)evolution* versions of 30.01.2018 or newer.

### 3.2.11 Glucose Meter Reader (GMR)



Figure 66: Glucose meter reader.

This user-friendly glucose meter measures reliable glucose level data (mg/dL) using blood samples taken from fingertips, palms, forearms, upper arms, or calves. The built-in colour LCD display displays the measured glucose level and allows this sensor to be used both as standalone device or as *biosignalsplux* sensor within [OpenSignals \(r\)evolution software](#). This sensor comes with 10 disposable single-use lancets and test strips to take and prepare the needed blood samples.

#### NOTE

This sensor is an adaptation of the 3<sup>rd</sup> party *CareSens™ II* Blood Glucose Monitoring System (*i-SENSO, Inc*) which provides compatibility with *biosignalsplux* devices. It can be used both as standalone device or as *biosignalsplux* sensor.

Please do also read the datasheet of the standalone device before using this sensor:  
[http://biosignalsplux.com/datasheets/telemedicine/caresens\\_ii.pdf](http://biosignalsplux.com/datasheets/telemedicine/caresens_ii.pdf)

#### How to connect your sensor to your biosignalsplux

Connect the sensor to the adapter box using the 3.5mm connector which comes pre-connected to the adapter box. When done, connect the outgoing UC-E6 cable to any of the available analog inputs of your biosignalsplux (see 2.3.2 *Analog Inputs*).

#### How to configure your sensor in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select the device you have your GMR sensor connected to. Select the channel of your sensor and set the sensor type to

*GLUC*<sup>7</sup> (click on the arrow in the channel's field that appears when you hover over the channel's field and select *GLUC* from the dropdown menu).

Activate the channel for signal acquisition by clicking on the circle in the channel field (must be blue).

### How to use your sensor

This sensor is designed to measure the glucose concentration in 5µL blood samples taken from fingertips, palms, forearms, thighs, upper arms, or calves.

#### WARNING

The test strips, lancets, and the disinfection cloths which come with your sensor are disposables and are intended for single use only.

Do not reuse test strips, lancets, and the disinfection cloths and dispose them after being used.

To start acquiring a signal with this sensor in *OpenSignals (r)evolution*, disconnect the sensor from your *biosignalsplux* and start the signal acquisition to avoid starting with measurement results from previous acquisitions (for more details see also the indications on the next page).

Follow the application instructions on the flyer provided with your sensor to ensure a correct and harmless use of this sensor during the preparation of the blood sample and the measurement.

Prepare your blood sample and use the test strip, as indicated on the flyer to measure the glucose level of the blood sample. The sensor requires 5 seconds to measure the glucose level; a countdown will be shown on the device display. The test strip must be held in the blood sample during the entire 5 seconds of the measurement process. If no error occurred, the device will now show the measured value on its display.

After a successful measurement, plug-in the biosignalsplux connector to your glucose meter reader. The device's display should now be displaying "Pc" and the signal in *OpenSignals* will now be at the measured value.

If configured correctly, your acquired signals should be similar to the signal displayed in Figure 67.

---

<sup>7</sup> The sensor type *GLUC* (glucose level) is only supported by *OpenSignals (r)evolution* versions of 30.01.2018 or newer.

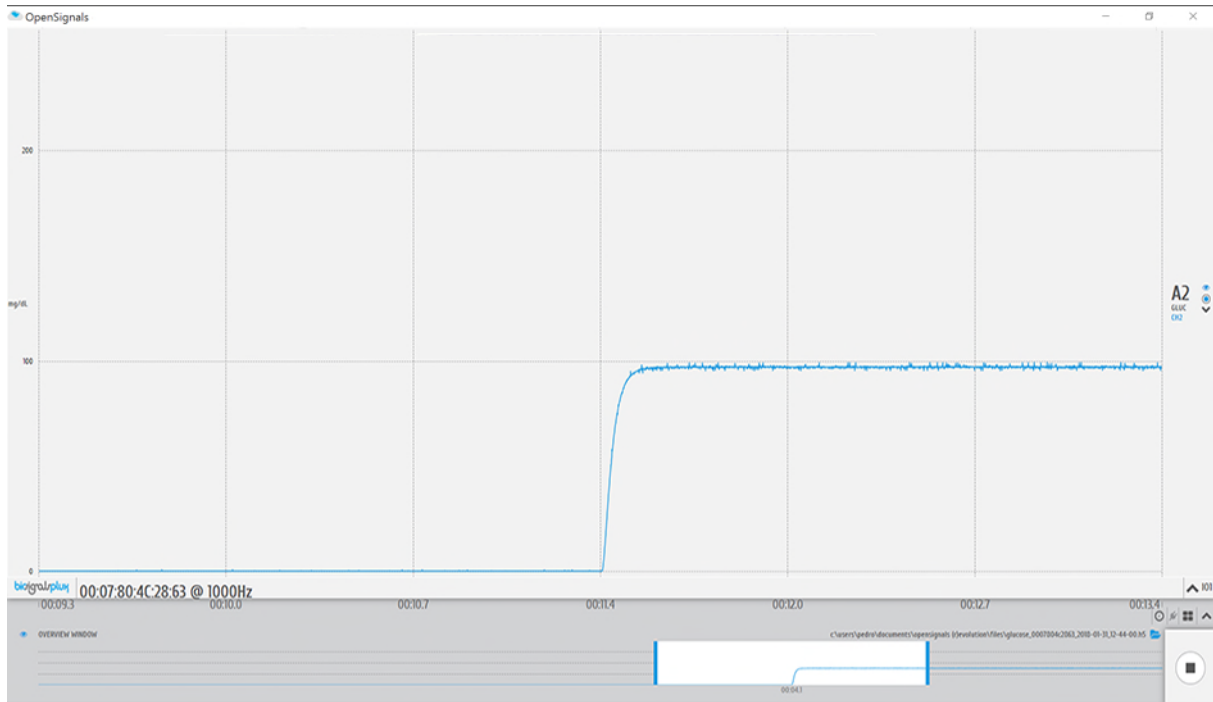


Figure 67: Glucose meter reader sample.

## Important Notes & Troubleshooting

### ***Initial values & effects of previous acquisitions***

When using this sensor with *biosignalsplux*, the value of the last measurement will be provided by the sensor and displayed in *OpenSignals (r)evolution*. The signal stays constant on the last measured value and only changes when new measurements are made.

This can cause your signal to start at the value of a previous measurement even if no actual measurement has been made during the acquisition session. To prevent initial values of previous acquisitions, disconnect the adapter of this sensor from the *biosignalsplux* and the sensor, measure the glucose level in your blood samples as indicated on the previous page, and connect the *biosignalsplux* and the sensor when done.

This will cause the sensor signal to start at 0 and rise to the newly measured result. Results of previous measurements will not be displayed in the current signal.

### ***Signal does not change in OpenSignals (r)evolution after new measurements***

After a successful measurement, the device should be displaying the measured value on its display. Connect the sensor with *biosignalsplux* using the adapter for this sensor. The display of the sensor should now be showing “Pc” and the signal in *OpenSignals (r)evolution* should be adjusted to the newly measured value.

If you are experiencing no signal changes after new measurements, disconnect the sensor from the adapter (the adapter can stay connected to the *biosignalsplux*). Restart your sensor by pressing the “M” two times and wait until the last measured value is displayed on its display. Reconnect the sensor with the *biosignalsplux* adapter (sensor display

should be showing “Pc”) and the signal will now be adjusted according to the last measured value.

### Error Codes

The sensor will provide error codes if measurements could not be made correctly. Depending on the type of error, the sensor will display one of the different error codes below:

Error Code	Issue	Solution
Er1	The test strip you are trying to use has already been used.	Dispose the used test strip and use a new test strip. Dispose the used lancet and use a new one for the new measurement.
Er2	The blood sample has been applied before the sensor has been ready for measurements.	Dispose the used test strip and Use a new test strip and wait for the lancet symbol to appear at the bottom of the display before applying your blood sample. Dispose the used lancet and use a new one for the new measurement.
Er3	Temperature recommended system range during test.	Take the system where the temperature is within the operating range (10-40°) and repeat test after 30 minutes.
Er4	The blood sample has an abnormally high viscosity or insufficient volume.	Repeat the test with a new test strip and adequate blood sample. Dispose the used lancet and use a new one for the new measurement. If required, increase the depth of the lancet and massage the fingertip before taking the blood sample, to increase the size of the blood sample.

Table 5: Glucose meter reader error codes.

## 4 Accessories

### NOTE

*biosignalsplux* Accessories need to be connected to the digital port of *biosignalsplux* devices. Please check if your device does have a digital port before considering using one of the following accessories (4-channel *biosignalsplux* devices do not have a digital port (can be added additionally); 8-channel *biosignalsplux* devices do have a digital port).

### NOTE

The configurations for *biosignalsplux* accessories are demonstrated by using PLUX's *OpenSignals (r)evolution* software. Please review the software manual for more detailed information about how to configure your device when using *OpenSignals*.

## 4.1 Actuators

### 4.1.1 Handheld Switch



Figure 68: Handheld switch.

This trigger device is useful to begin acquisition via Bluetooth to OpenSignals (or any other custom software) or to manually start offline acquisitions stored in the hub's internal memory when no Bluetooth connection is available.

#### How to connect your accessory to your biosignalsplux

The handheld switch needs to be connected to the digital port of your device (see 2.3.4 *Digital Port*).

#### How to configure your handheld switch in OpenSignals (r)evolution to mark events

Input devices, such as the handheld switch, do not require to be configured in *OpenSignals (r)evolution* if their intended use is to mark specific actions during an acquisition. In this case, their input state can be seen in *OpenSignals'* real-time acquisition mode in the information bar located right below the acquired signals (circle to the left of *INPUT DIGITAL*). The digital input circle will turn blue if a digital input has been received (handheld switch pressed) or be kept empty if no digital input has been received (handheld switch not pressed; see Figure 69)

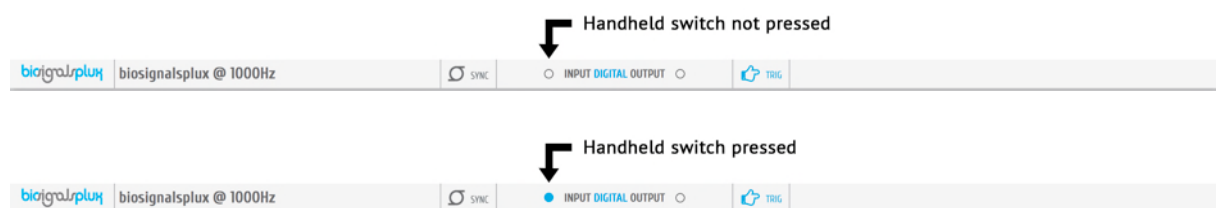


Figure 69: Digital input states.



The received inputs will be visualized in an extra channel named *IO1* in the visualization mode.

### How to configure your handheld switch in OpenSignals (r)evolution to trigger acquisitions

If the intended use of the handheld switch is supposed to trigger the start of an acquisition, it is needed to turn on this feature in the device manager. For this, open the *OpenSignals (r)evolution* device manager and select the device you have your handheld switch connected to. In the device's panel, click on the circle next to *TRIGGER* to activate the trigger feature (circle must be blue; see *Figure 70*).

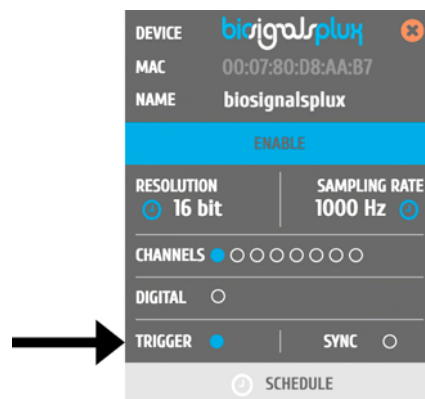


Figure 70: Trigger configuration.

In the information bar of *OpenSignals*' real-time acquisition mode (located right below the acquired signals), the state of the trigger feature is displayed (see *Figure 71*).

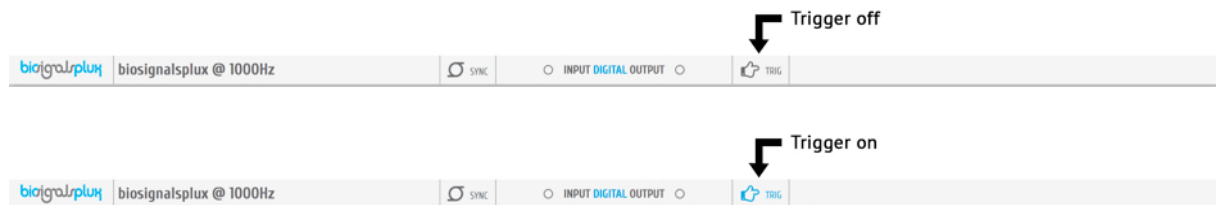


Figure 71: Trigger state.

### Accessory specifications

Please read the datasheet of handheld switch carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/BTN\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/BTN_Sensor_Datasheet.pdf)

### 4.1.2 Foot Switch

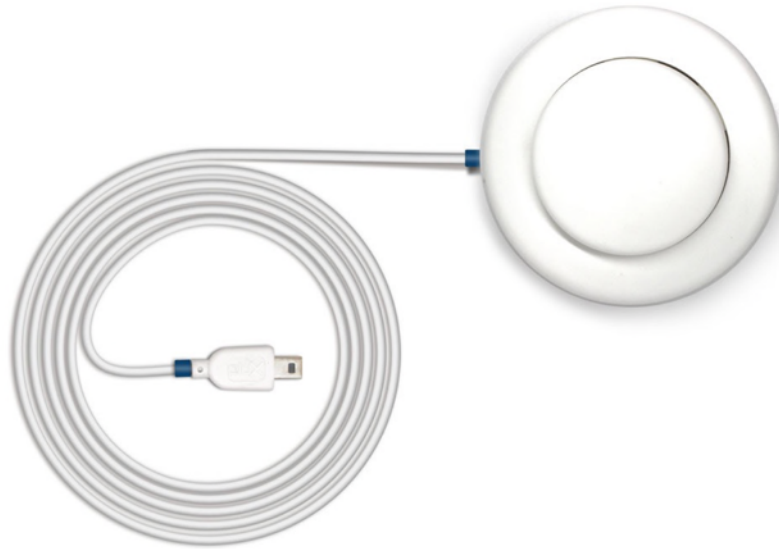


Figure 72: Foot switch.

This trigger device is useful to begin acquisition via Bluetooth to OpenSignals (or any other custom software) or to manually start offline acquisitions stored in the hub's internal memory when no Bluetooth connection is available.

#### How to connect your accessory to your biosignalsplux

The foot switch needs to be connected to the digital port of your device (see 2.3.4 Digital Port).

#### How to configure your foot switch in OpenSignals (r)evolution to mark events

Input devices, such as the foot switch, do not require to be configured in *OpenSignals (r)evolution* if their intended use is to mark specific actions during an acquisition. In this case, their input state can be seen in *OpenSignals*' real-time acquisition mode in the information bare located right below the acquired signals (circle to the left of *INPUT DIGITAL*). The digital input circle will turn blue if a digital input has been received (foot switch pressed) or be kept empty if no digital input has been received (foot switch not pressed; see Figure 73).

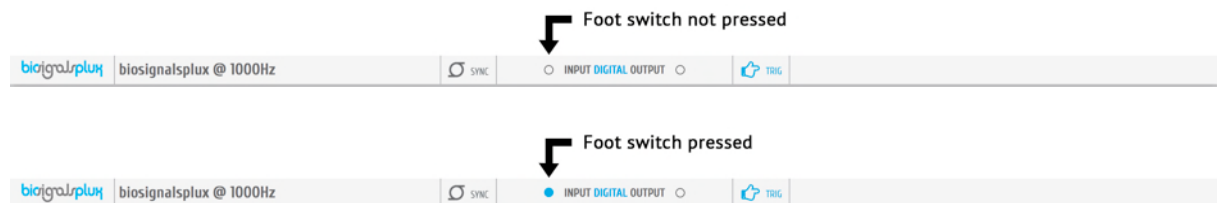


Figure 73: Digital input states.

The received inputs will be visualized in an extra channel named *IO1* in the visualization mode.

## How to configure your foot switch in OpenSignals (r)evolution to trigger acquisitions

If the intended use of the foot switch is supposed to trigger the start of an acquisition, it is needed to turn on this feature in the device manager. For this, open the *OpenSignals (r)evolution* device manager and select the device you have your foot switch connected to. In the device's panel, click on the circle next to *TRIGGER* to activate the trigger feature (circle must be blue; see *Figure 74*).

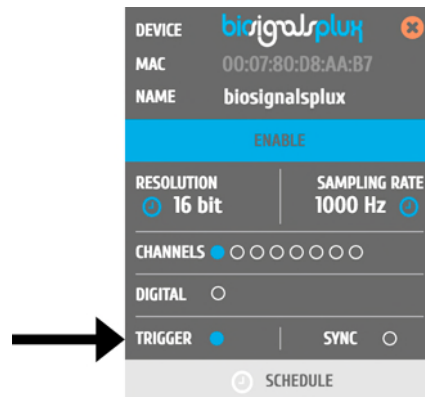


Figure 74: Trigger configuration.

In the information bar of *OpenSignals*' real-time acquisition mode (located right below the acquired signals), the state of the trigger feature is displayed (see *Figure 75*).

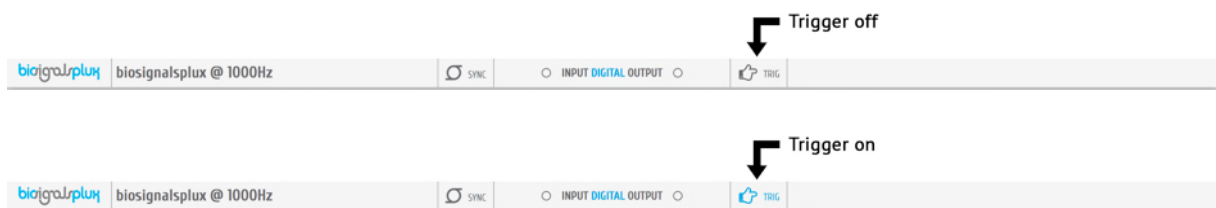


Figure 75: Trigger state.

### 4.1.3 Light-Emitting Diode (LED)



Figure 76: LED.

The LED is typically used to provide visual feedback to the user. A common need when working with biosignals is the synchronization of the recorded data with external recording devices (e.g. a video camera). If applied to a camera lens, the LED sensor can be used to introduce common markers in the recording, hence providing a synchronization source. The LED sensor can also be useful for optical synchronization with third-party devices (provided that the third-party device has a photo detector), in applications where it is important to have electrical decoupling between devices.

#### **How to connect your accessory to your biosignalsplux**

The LED needs to be connected to the digital port of your device (see 2.3.4 *Digital Port*).

#### **How to control your LED in OpenSignals (r)evolution**

Output devices, such as the LED, do not require to be configured in *OpenSignals (r)evolution*. However, it is possible to select their initial state which can later be changed in the information bar of *OpenSignals*' real-time acquisition mode which is located right below the acquired signals (circle to the right of **DIGITAL OUTPUT**).

To select an initial state, open the *OpenSignals (r)evolution* device manager and select the device you have your LED connected to. In the device's panel, click on the circle next to **DIGITAL** to turn on (blue circle) or off (empty circle) the LED for the start of your signal acquisition (see Figure 77).

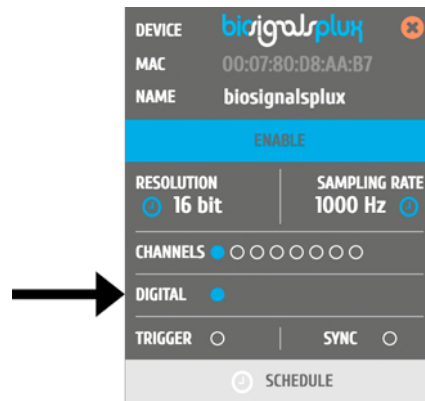


Figure 77: Initial state of the digital output (here: on).

To change the output state of the LED during the acquisition, click on the circle next to **DIGITAL OUTPUT** in the information bar of the real-time acquisition mode. Here, again, the LED will be turned on if the circle is blue and off if the circle is empty (see Figure 78).

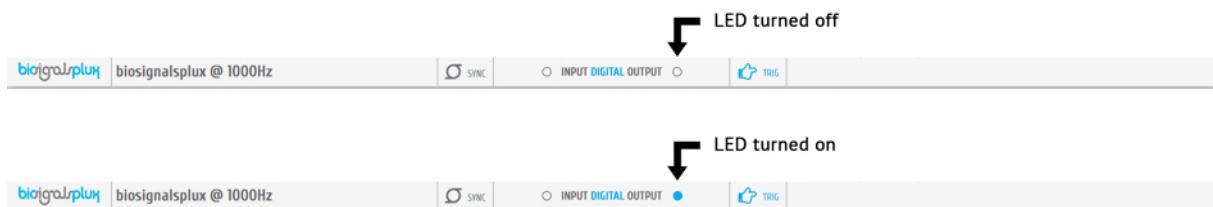


Figure 78: Digital output states for LED.

### OpenSignals (r)evolution Add-On: Video Synchronization

The *Video Synchronization* add-on has been designed for research applications which involve recording data from sources other than the biosignal acquisition hardware devices (e.g. video camera). Given that the biosignal hardware and the camera are independent recording sources, a common problem when replaying the recording session is the synchronization of both. This plugin was created to provide an easy way to replay biosignal data synchronously with video using this LED (or the light sensor (LUX); see 3.1.9 Light (LUX) ).

This add-on is included in the *biosignalsplux Professional* kit (see 1.3 *biosignalsplux Professional*) and the *biosignalsplux Researcher* kit (see 1.2 *biosignalsplux Researcher*), and can also be bought additionally for the use with *biosignalsplux* hubs and wearables which can be used with this light sensor.

Please visit the following website for more information about this add-on:

<http://www.biosignalsplux.com/index.php/en/software/add-ons>

### **Accessory specifications**

Please read the datasheet of LED carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/LED\\_Actuator\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/LED_Actuator_Datasheet.pdf)

## 4.2 Synchronization & Additional Digital Ports

### 4.2.1 Digital Synchronization Cable

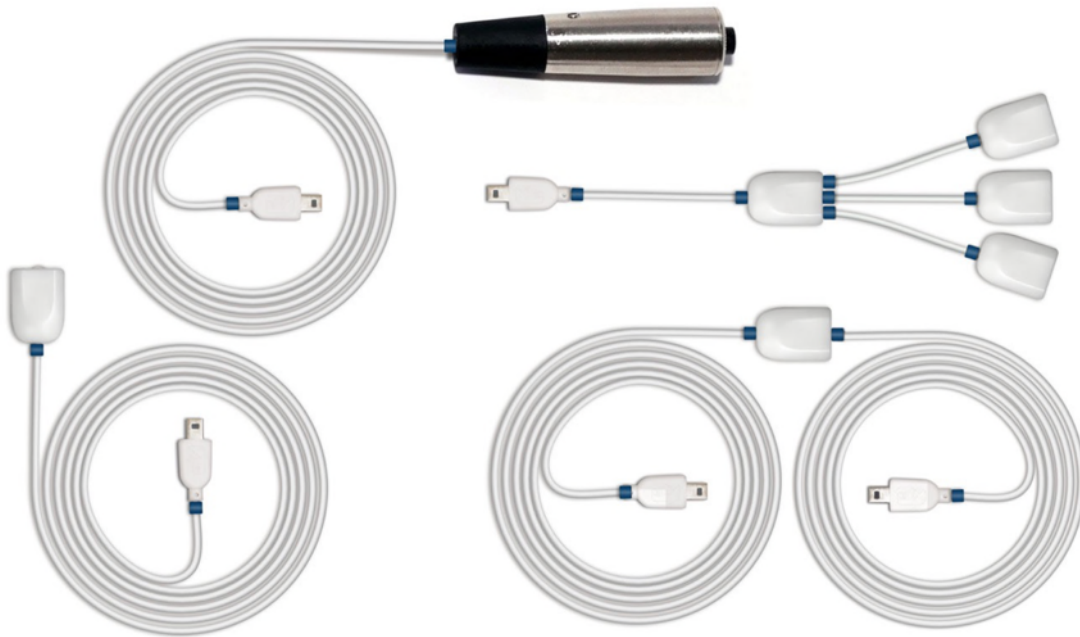


Figure 79: Sync cable & kit.

The multi sync splitter accessory meets your multi-device acquisition needs. By using digital synchronization cable(s), this accessory allows you to connect *biosignalsplux* devices with digital ports together to collect up to 24 channels at the same time (by connecting up to 3 HUBs together).

#### NOTE

If you are using more than 2 devices, follow the instructions provided in *4.2.2 Multi Sync Splitter*).

#### How to connect your accessory to your biosignalsplux

The digital synchronization cable needs to be connected to the digital ports of the devices that are being used for the multi-device acquisition (see *2.3.4 Digital Port*).

#### How to configure synchronized acquisitions in OpenSignals (r)evolution

Open the *OpenSignals (r)evolution* device manager and select one of the devices you want to use for the multi-device acquisition. In the device's panel, click on the circle next to *SYNC* to turn on (blue circle) or off (empty circle) the synchronization function to synchronize the acquisition of your devices (see *Figure 80*). This function must be active to ensure synchronized multi-device acquisitions without signal drifts. Repeat this step for the second device that is being used for the multi-device acquisition.

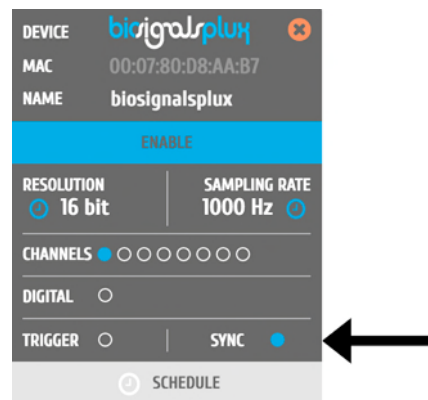


Figure 80: Activate synchronization feature.

### Accessory specifications

Please read the datasheet of SYNC kit carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/SYNC\\_Accessory\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/SYNC_Accessory_Datasheet.pdf)



### 4.2.2 Multi Sync Splitter



Figure 81: Multi sync splitter.

The multi sync splitter accessory meets your multi-device acquisition needs. By using digital synchronization cable(s), this accessory allows you to connect *biosignalsplux* devices with digital ports together to collect up to 24 channels at the same time (by connecting up to 3 HUBs together).

#### **How to connect your accessory to your biosignalsplux**

The multi sync splitter needs to be connected to the digital port of one of the devices that are being used for the multi-device acquisition (see 2.3.4 *Digital Port*). When done, link the other device(s) with the multi sync splitter by connecting digital synchronization cable(s) (see 4.2.1 *Digital Synchronization Cable*) to the digital port(s) of the other *biosignalsplux* devices and to the one of the three available inputs of the multi sync splitter.

#### **How to configure synchronized acquisitions in OpenSignals (r)evolution**

Open the *OpenSignals (r)evolution* device manager and select one of the devices you want to use for the multi-device acquisition. In the device's panel, click on the circle next to *SYNC* to turn on (blue circle) or off (empty circle) the synchronization function to synchronize the acquisition of your devices (see Figure 82). This function must be active to ensure synchronized multi-device acquisitions without signal drifts. Repeat this step for all devices that are used for signal acquisition.

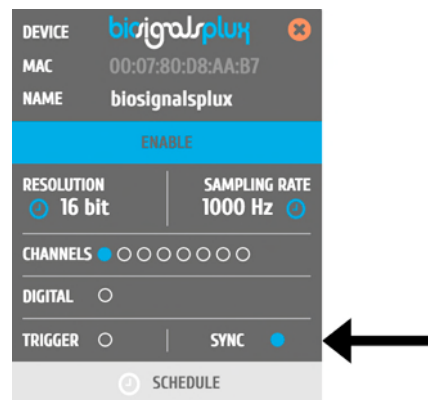


Figure 82: Activate synchronization feature.

### Accessory specifications

Please read the datasheet of Multi Sync-Splitter carefully before using it the first time. The datasheet can be downloaded here:

[http://biosignalsplux.com/datasheets/SYNC\\_Accessory\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/SYNC_Accessory_Datasheet.pdf)

## 4.3 3rd Party Compatibilities

*biosignalsplux* devices allow the usage and acquisition of data from 3<sup>rd</sup> party sensors, using the available [biosignalsplux breakout PCB](#). This accessory allows to connect analog or digital third party sensors to the *biosignalsplux* hub or *biosignalsplux* wearables that lie within the **specified and compatible electric values of the *biosignalsplux* HUB**. Please read [the breakout PCB section of this manual before](#) before trying to use any 3<sup>rd</sup> party sensor with *biosignalsplux*.

### 4.3.1 I/O Breakout Cable

#### WARRANTY WARNING

Usage of this breakout cable input interface **VOIDS THE ELECTRICAL WARRANTY** of your device and sensors.

#### DISCLAIMER

**BEWARE** when using this accessory as to preserve electrical isolation of the user.

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.

This accessory allows the connection, within the specified electric values, of a wide range of analog or digital third party sensors to the *biosignalsplux* hub. This allows, for instance, the acquisition and visualization in real time on OpenSignals of a third party sensor, using the *biosignalsplux* hub.



#### Specifications

Maximum Output Current: 200mA (with no other sensors connected to the hub)  
Input Voltage Range: 0 – 3V  
Output Voltage Range: 0 – 3V or  $\pm 1.5V$  (if reference is GND)

Check the table below and the breakout cable datasheet (see annexes) for detailed information about the pinout configuration for the analog ports (standard sensor channels) and digital ports (8-channel *biosignalsplux* devices only) **BEFORE CONNECTING YOUR SENSOR TO YOUR DEVICE** to avoid damaging your PLUX device.

ANALOG PORT	
V-	0V
GND	1.5V
V+	3V
IN	Analog input

DIGITAL PORT	
V-	0V
GND	Digital output
V+	3V
IN	Digital input

Table 6: Pinout configuration for analog & digital ports.

### 4.3.2 Sensor Breakout PCB

#### WARRANTY WARNING

Usage of this breakout cable input interface **VOIDS THE ELECTRICAL WARRANTY** of your device and sensors.

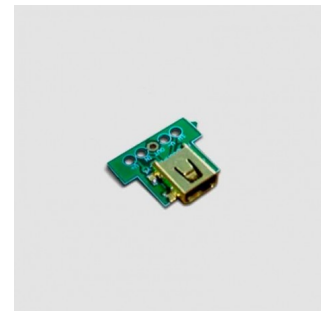
#### DISCLAIMER

**BEWARE** when using this accessory as to preserve electrical isolation of the user.

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.

This accessory allows easy access, within the specified electric values, to the pins on *biosignalsplux* sensors and actuators for interfacing them with third-party systems.

Check the sensor datasheets **before** using this accessory to avoid any damage of your system or your sensor(s).



ANALOG SENSOR	
V-	GND
GND	1.5V (to sensor)
V+	3V (to sensor)
IN	Sensor output

DIGITAL SENSOR	
V-	GND
GND	Sensor output
V+	3V (to sensor)
IN	1.5V (to sensor)

Table 7: Pinout configuration for analog & digital ports.

## 5 ergoplux

Work-related musculoskeletal disorders are a world problem, concerning health, social and economics sectors. In fact, the high prevalence of such disorders in the spine and upper limbs have been documented by several studies associated with to a higher number of work absences and dissatisfaction, which leads to significant social and economic costs.

With this in mind, we designed the [ergoplux Explorer](#) and the [ergoplux Researcher](#) kits were designed to objectively track and measure work-related stress on workers conducting physical work processes by providing reliable data for ergonomists to detect, prevent, and/or improve high-risk work activates. This kit aims to help decrease and prevent the amount of work-related musculoskeletal disorders.

### 5.1 Hardware

**ergoplux Explorer** uses the *OpenSignals (r)evolution* software to acquire and visualize data from up to 8 electromyography sensors simultaneously and the *Electromyography Analysis* add-on to extract statistical information from the acquired signals to evaluate the stress workers are exposed to in further detail. Additionally, the *Video Synchronization* add-on allows the users to record videos of the workers during the signal acquisition sessions to visualize all signals synchronously with the recorded video for post-acquisition analysis purposes (e.g. movement analysis).

**ergoplux Researcher** uses the *OpenSignals (r)evolution* software and the *Muscle Load Analysis* software add-on to track the muscular stress of workers by acquiring electromyography signals (up to 8 sensors simultaneously) and by analyzing the muscle contraction intensities over time. The *Electromyography (EMG) Analysis* add-on allows extracting statistical information from the acquired signals to evaluate the stress workers are exposed to in further detail. Additionally, the *Video Synchronization* add-on allows the users to record videos of the workers during the signal acquisition sessions to visualize all signals synchronously with the recorded video for post-acquisition analysis purposes (e.g. movement analysis).

## 5.2 Software

ergoplux systems come with software add-ons for the *OpenSignals (r)evolution* software.

### NOTE

It is required for this software to be installed on your computer. You can download *OpenSignals (r)evolution* here:

<http://biosignalsplux.com/en/software>

We do also recommend to check the *OpenSignals (r)evolution* documentation to take advantage of all features:

<http://biosignalsplux.com/en/learn/documentation>

### 5.2.1 Video Synchronization Add-On

Available in *ergoplux Explorer kits* & *ergoplux Researcher Kits*.

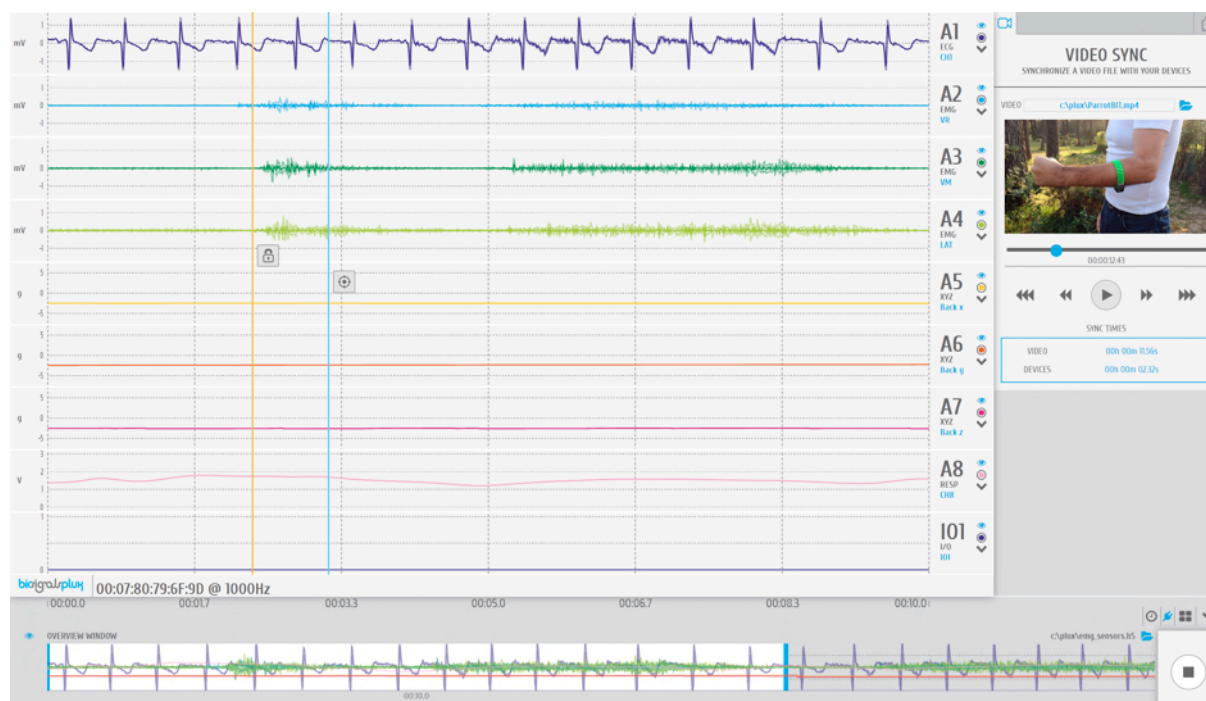


Figure 83: Video Synchronization Add-on.

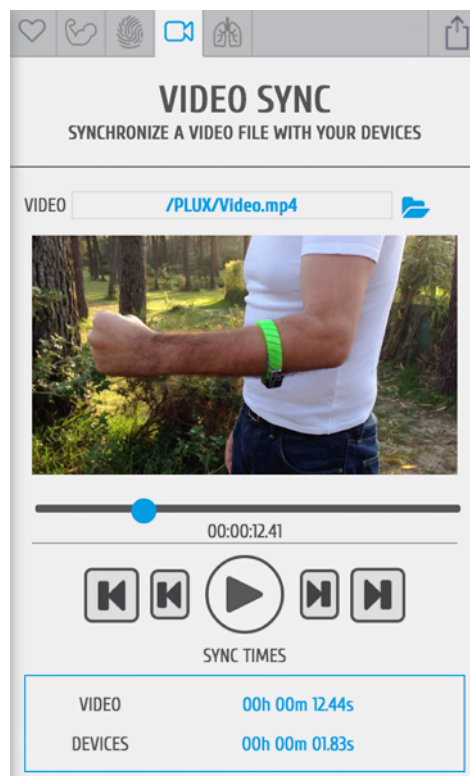
Multimodal data acquisition in human studies usually involves recording data from sources other than the biosignal acquisition hardware devices (e.g. video camera). Given that the biosignal hardware and the camera are independent recording sources, a common problem when replaying the recording session is the synchronization of both. This plugin

was created to provide an easy way to replay biosignal data synchronously with video using for example our LED accessory to provide a common event to both devices.

In use with ergoplux, this add-on is useful to synchronize video material recorded during signal acquisition sessions in real-life applications for further movement and stress analysis.

This add-on is only available in *OpenSignals (r)evolution's* signal visualization mode.

## ADD-ON CONFIGURATION



## DEVICES & CHANNELS

The video synchronization add-on does not have to be configured to a specific channel or device. The video mark that synchronizes the acquired all available signals with the selected video. It affects all acquisition channels equally.

## VIDEO PATH

Click on the folder next to the video field and select the acquisition video.

## SYNC TIMES

Sync times displays the information of the video mark which synchronizes the video at the indicated time with a selected point in the acquired signals (see detailed information below).

Video:            Locked synchronization point in the video timeline  
Devices:        Locked synchronization point in the acquired signals



### **Locked synchronization point**

The lock marks the synchronization point between the video and the acquired signals. Stop the video at the time point where the synchronization input (e.g. visual input via LED) was set in the video. Move the lock to the time point in your acquisition where the acquired signal overlap with your recorded video and click on the lock fix this point as the synchronization point between your video and your acquisitions.



### **Current position**

The aim icon uses the locked synchronization point as a reference point and displays the current position of your acquired signals compared to the acquisition video. It will only be displayed in the signal window if the displayed signals lie within the synchronized video interval.



## 5.2.2 Electromyography Analysis Add-On

*Available in ergoplux Explorer kits.*

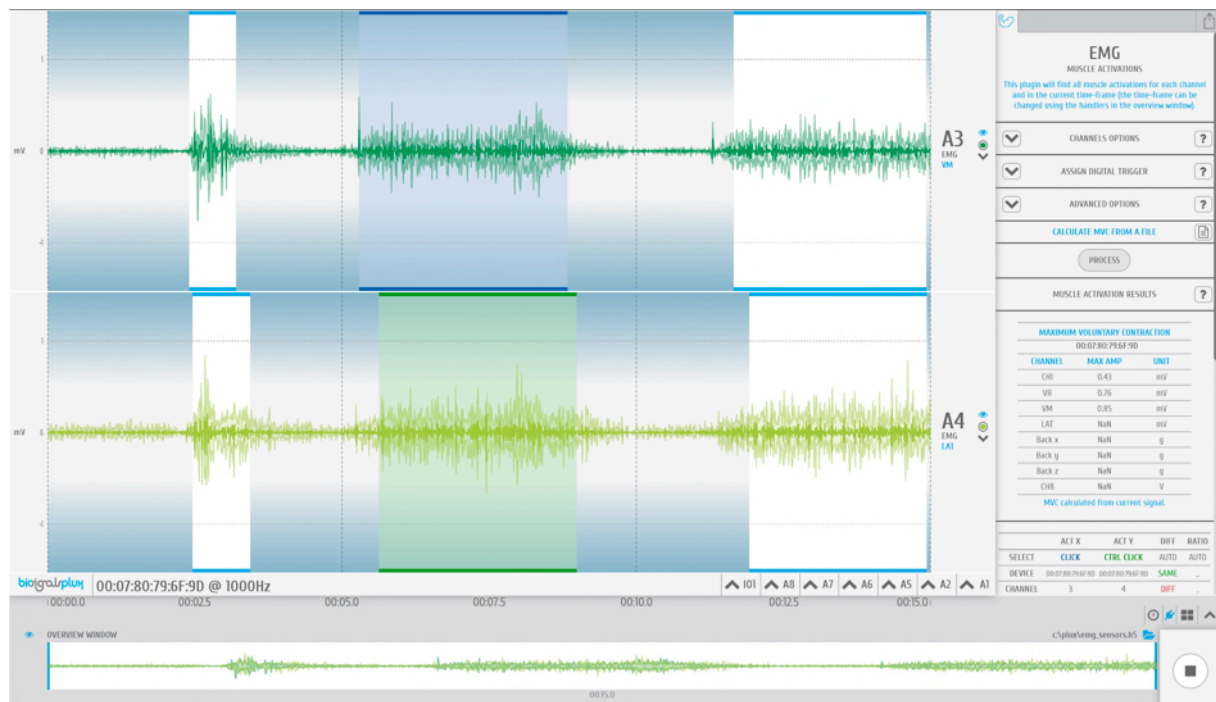


Figure 84: OpenSignals EMG Analysis Add-On

Muscle activity is usually assessed using temporal and spectral features. With this plugin, you will be able to extract useful statistical information from Electromyography (EMG) sensor data. Its automatic onset detection algorithm enables the analysis of each individual muscle activation event, in addition to the overall analysis of the recording session. Timings analysis can also be done for each activation relative to a reference muscle activation.

The EMG analysis add-on offers the possibility to process all available EMG channels (hidden and visible channels), all visible channels of the acquisition, or to select a specific device and channel to be processed by this add-on. This add-on is only available in *OpenSignals (r)evolution's* signal visualization mode.

## ADD-ON CONFIGURATION

**EMG**  
MUSCLE ACTIVATIONS

This plugin will find all muscle activations for each channel and in the current time-frame (the time-frame can be changed using the handlers in the overview window).

**CHANNELS OPTIONS**

UNIT  
Millivolt

**PROCESSED CHANNELS**

PROCESS ALL EMG CHANNELS  
PROCESS ALL VISIBLE CHANNELS  
PROCESS SPECIFIC CHANNEL

**ASSIGN DIGITAL TRIGGER**

FIND ALL MUSCLE ACTIVATIONS  
FIND ACTIVATIONS FROM DIGITAL ON TO DIGITAL OFF  
FIND ACTIVATIONS FROM DIGITAL ON TO 0.3 SEC

**ADVANCED OPTIONS**

CALCULATE MVC FROM A FILE  
PROCESS

**MUSCLE ACTIVATION RESULTS**

MAXIMUM VOLUNTARY CONTRACTION		
00:07:80:D8:AA:B7		
CHANNEL	MAX AMP	UNIT
CH1	-	V

Figure 85: EMG add-on.

### DEVICES & CHANNELS

The EMG analysis add-on offers the possibility to process all available EMG channels (hidden and visible channels), all visible channels of the acquisition, or to select a specific device and channel to be processed by this add-on. Note that processing all visible channels will also process non-EMG sensor data, however, this can be useful to process RAW EMG channels.

Additionally, it can be selected whether the channels units should be set to microvolt or millivolt in the *UNIT* dropdown menu.

### ASSIGN DIGITAL TRIGGER

The processing interval selects the time interval of the EMG data that is to be processed. It can be changed by manually inputting the start and end point of the acquisition session into the time fields in the configuration window or by changing the size of the visualization interval in the overview window.

## ASSIGN DIGITAL TRIGGER

In the *ASSIGN DIGITAL TRIGGER* options it is possible to select if the add-on should find all available muscle activations or if it should find activations depending on digital input and output signals, i.e. trigger signals.

The *FIND ACTIVATIONS FROM DIGITAL ON TO DIGITAL OFF* option will find all activations within the time frames where digital inputs have been received, for example, during the time frame a pushbutton has been being pressed.

The *FIND ACTIVATIONS FROM DIGITAL ON TO ... SEC* will find all activations within the specified duration after the first digital inputs received, for example, beginning at the moment a pushbutton has been pressed.

## ADVANCED OPTIONS - Filters

The advanced options allow you to change the parameters which are being used in the activation detection algorithm to adjust the processing to your acquisition. In this option, you can select if you want to use a lowpass, highpass or a bandpass to be applied on your signal and set the respective cutoff frequencies for the selected filter.

To use a lowpass filter, click on the *LOWPASS* button and enter the preferred cutoff frequency for this filter in the *CUTOFF – LOW* field and enter the order of the filter in the *ORDER* field.

To use a highpass filter, click on the *HIGHPASS* button and enter the preferred cutoff frequency for this filter in the *CUTOFF – HIGH* field and enter the order of the filter in the *ORDER* field.

To use a bandpass filter, click on the *BANDPASS* button and enter the preferred cutoff frequency for the lowpass component of this filter in the *CUTOFF – LOW* field and enter the preferred cutoff frequency for the highpass component of this filter in the *CUTOFF – HIGH*. Enter the order of the filter in the *ORDER* field.

## ADVANCED OPTIONS – Process X Channel

This option allows you to apply the statistical algorithms of this add-on to a selected channel X within the same time intervals of another channel without any activation dependency of channel X. The add-on will search for activations on a selected EMG channel (click on the channel to select) and analyze the selected channel X at the same time intervals where activations have been found in the selected EMG channel even if there are no activations or activation triggering activities within these time intervals in channel X (e.g. muscle is relaxed in during this interval).

With this option it is possible to compare two EMG signals within the same time intervals without any activation dependencies.

## MCV – MAXIMUM VOLUNTARY CONTRACTION

The maximum voluntary contraction (MVC) will be calculated for each channel based on the EMG maxima of your selected EMG signals.

The MVC acquisition can also be done in a separate signal acquisition session/file. This can be useful to use when doing several signal acquisitions to ensure that the analysis of all files and signals are done with the same reference values – the MVC values.

For this, start an acquisition and acquire your data which are being used as MVC values for later analysis and save your acquisition. To use the MVC data from this acquisition in another acquisition, click on the document icon in the *CALCULATE FROM A FILE INSTEAD* field and select the *OpenSignals (r)evolution* file which contains the MVC signal data. *OpenSignals (r)evolution* will then calculate the MVC value from the selected file.



Select *OpenSignals (r)evolution* file to calculate MVC values from file

Each channel's MVC value are listed in the table below *MAXIMUM VOLUNTARY CONTRACTION*.

## MUSCLE ACTIVATION RESULTS

Click on the *PROCESS* button to process all signals according to the set configuration and all found activations will be visualized in the processed channels (white frames).

To display all statistical information about one or two specific activations, click on the first activation (left mouse button). The white frame turns into a blue frame and all statistical information about this activation will be listed in the *ACT X* column of the analysis results. When done, select the second activation of your choice by holding the *CTRL* key of your keyboard and click on the activation (left mouse button). The white frame turns into a green frame and all statistical information about this activation will be listed in the *ACT Y* column of the analysis results.

The results table displays general information about the source of this signal (device & channel) as well as general information about the duration and times of your acquisition. All activation specific data is displayed below the given general information (e.g., activation number, duration).

### 5.2.3 Muscle Load Add-On

*Available in ergoplux Explorer kits & ergoplux Researcher Kits.*

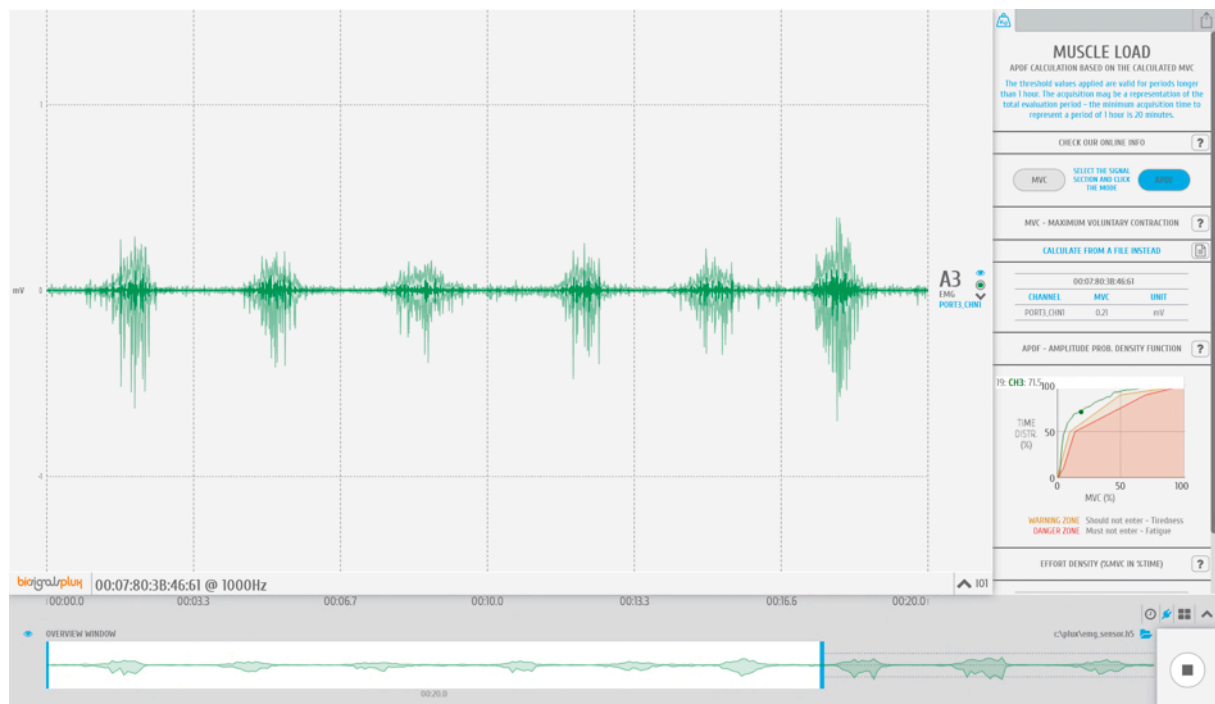


Figure 86: OpenSignals Muscle Load Add-On.

This add-on evaluates the muscular load that the muscles are subjected during a normal work day in real-time and after signal acquisition sessions. It measures the static, median and high intensity levels and displays the amplitude probability density function which helps detecting whether the worker is working within ranges that are safe or risky.

This add-on works both offline and online. It is available in *OpenSignals (r)evolution's* signal visualization mode and in the signal acquisition mode.

#### NOTE

For detailed information about the scientific background of this add-on, please check the section 5.3 *Scientific Background – Muscle Load*.

## ADD-ON CONFIGURATION

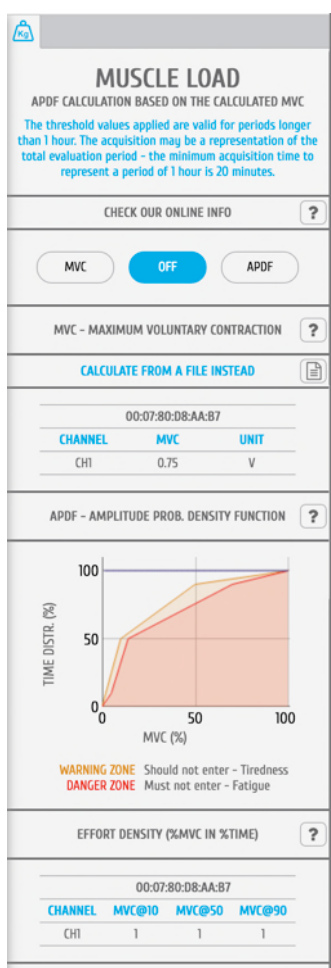


Figure 87: Muscle Load add-on.

## DEVICES & CHANNELS

The Muscle Load add-on processes all available and active channels.

Active channels are all channels which have not been hidden and are therefore visualized in the signal visualization mode.

## MVC – MAXIMUM VOLUNTARY CONTRACTION

At the beginning of each acquisition it is needed calibrate the add-on in order for it to provide reliable data. To do so, click on the *MVC* button (maximum voluntary contraction) and let the subject contract the muscle which is being monitored to its maximum. Make sure the muscle can be contract without any restrictions for the calibration to be done properly. This contraction will provide the value of the maximum possible contraction of the muscle. This value will be the reference point for the signal acquisition and processing. Each channel's MVC value are listed in the table below *MVC – MAXIMUM VOLUNTARY CONTRACTION*.

The maximum voluntary contraction (MVC) will be calculated for each channel based on the EMG maxima of your selected EMG signals.

The MVC acquisition can also be done in a separate signal acquisition session/file. This can be useful to use when doing several signal acquisitions to ensure that the analysis of all files and signals are done with the same reference values – the MVC values.

For this, start an acquisition and acquire your data which are being used as MVC values for later analysis and save your acquisition. To use the MVC data from this acquisition in another acquisition, click on the document icon in the *CALCULATE FROM A FILE INSTEAD* field and select the *OpenSignals (r)evolution* file which contains the MVC signal data. *OpenSignals (r)evolution* will then calculate the MVC value from the selected file.



Select *OpenSignals (r)evolution* file to calculate MVC values from file

### **APDF – AMPLITUDE PROBABILITY DENSITY FUNCTION**

After this acquiring the MVC, click on the *APDF* button to start the amplitude probability density function. This function calculates the cumulative percentage histogram of the enveloped data in terms (%) of the MVC and displays if the muscle load that the muscle(s) are subjected during the current task (represented by the blue lines in the graph) are causing muscle tiredness (see *WARNING ZONE* area in Figure 87) or muscle fatigue (see *DANGER ZONE* area in in Figure 87). Low to no muscle load will shift the blue line to the top left corner of the graph, will increasing muscle load and muscle load over duration will shift the graph into the warning and danger zones.

### **EFFORT DENSITY (%MVC IN %TIME)**

This function displays the cumulated effort in terms (%) of the MVC at 10, 50 and at 90% of the time (blue lines on chart) and displays all values of all devices and sensors in a table.

## 5.3 Scientific Background – Muscle Load

The scientific background for the *Muscle Load* add-on is based on B. Jonsson's paper from 1982 "*Measurement and Evaluation of Local Muscular Strain in the Shoulder During Constrained Work*".

Please find below detailed information about this work and the Amplitude Probability Distribution Function for deeper understanding of how the functionality of the *Muscle Load* add-on.

### 5.3.1 Amplitude Probability Distribution

Proper electromyography signal processing can provide a reference for the analysis of the relationship between work and required muscular load. Jonsson (1982) described a technique in which the frequency of occurrence of a particular level of EMG is calculated, generating a curve of the probability distribution function of amplitude (APDF). The APDF is the distribution of the muscle contraction levels during a certain observation period.

The APDF concept was originally developed to extract information from EMG records of muscular activity and has been used to analyze EMG in many Ergonomics studies.

### 5.3.2 Computation

The determination of APDF allows to obtain the profile of muscle tension that workers are subject during a work period. The determination process involves the following sequence:

- Calculation of the envelope of the EMG signal obtained by rectifying and smoothing using a low pass filter.
- Determination of the histogram of the EMG signal amplitude for each muscle during the execution of the task to be studied relative to the maximum voluntary contraction (MVC) of the same muscle;
- Calculation of the cumulative histogram of EMG amplitude distribution and mapping of the probability values regarding the distribution of the muscle for MVC. This way, the amplitude of EMG, as well as the probability distribution is related to the MVC, which allows comparing between several muscles or between several tasks as well as the estimation of the average APDF function groups of workers and/or tasks.



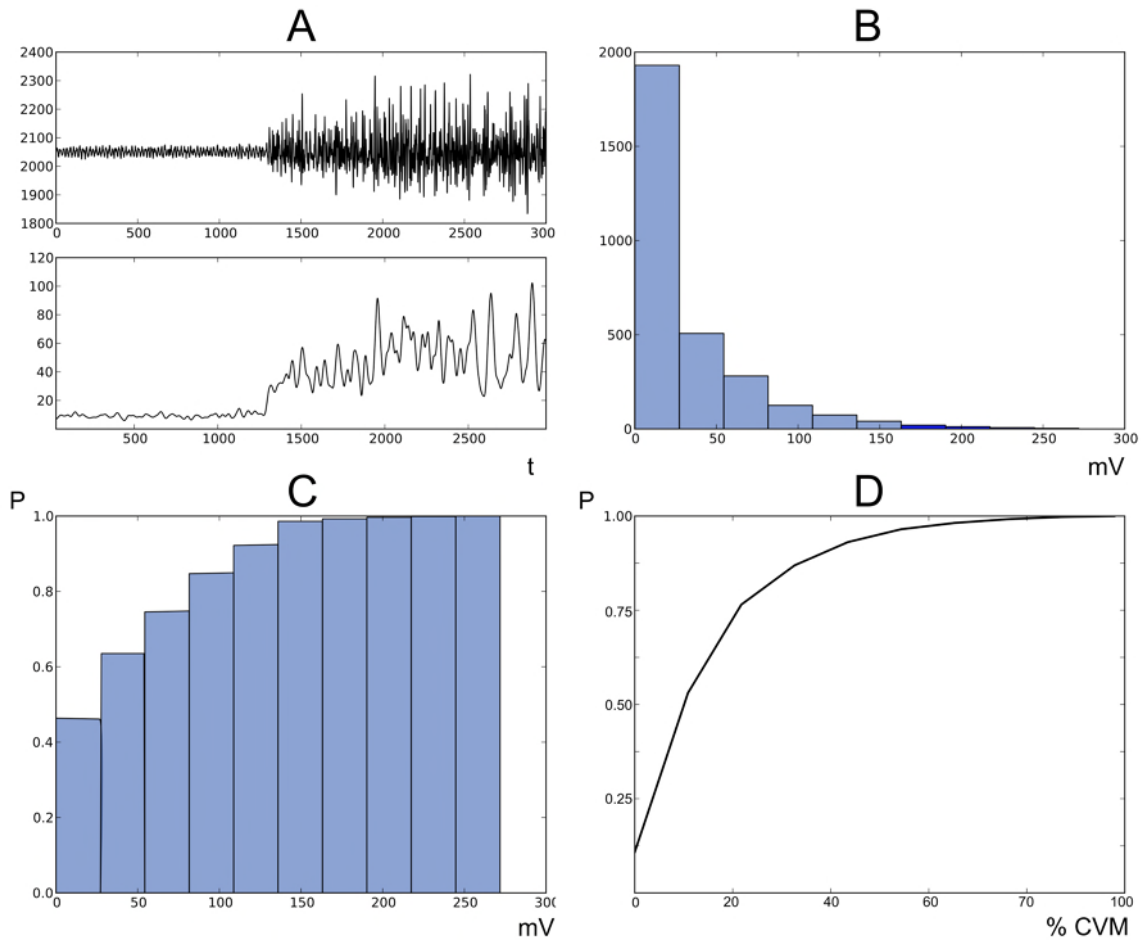


Figure 88: EMG signal processing - Collecting samples (A); Construct the amplitude histogram (B) and the cumulative amplitude (C), which will be converted into an APDF curve. [Adapted from Jonsson (1982)].

The final results of the APDF processing allows to evaluate the relative intensity of different tasks in a workstation as a whole or even the sequence realized for workers during their turn.

The amplitude probability of a certain level of contraction is the muscle's electrical activity probability lower or equal than the level of contraction. The amplitude probability of a certain level can be expressed as the time interval where the signal is less or equal than that level. If the electromyographic activity amplitude is expressed in percentage of the MVC's calculated value, the amplitude probability distribution is related to the contractions during the work day.

The contraction level of electromyographic signals, which has an amplitude distribution probability that initiates at a probability  $P=0$  level, indicates the lowest contractile activity that occurred throughout the work period. This corresponds to the basal static of contraction level which is, in most of the cases, zero or quite close to zero, especially in long-term acquisitions. A typical situation of this type of contraction is the interruptions between active periods of work.

The highest contraction level of EMG amplitude distribution probability curve corresponds to a probability of  $P=1$ , indicating the highest level recorded over the work

period. In cases where the highest value for muscle activity estimation might exceed 50% of the MVC, the normalization of EMG signals must be performed with a direct assessment of 100% from the MVC. Otherwise, one might establish an underestimate of APDF.

The average level of contraction associated with a probability of  $P=0.5$  indicates the average value of the contraction developed during the work period. Usually, this average level tends to the average contraction value when obtained from the EMG integration or electromyographic signal's RMS detection.

EMG amplitude distribution probability curve will feature how muscle behaves during study period. Each type of work presents a characteristic profile concerning the amplitude distribution probability curve.

When electromyographic records are used to obtain muscle activity levels' evaluation, criteria must be taken into account in order to define which obtained values for muscle tension levels are acceptable and non-acceptable according to the performed occupational tasks.

According to muscle fatigue studies, when performing static and dynamic tasks, a set of limit values were suggested for the work performed over periods longer than one hour (Jonsson, 1982):

- Static contraction level must not exceed 2% of the MVC and cannot overcome 5% of the MVC;
- The average level must not exceed 10% of the MVC and cannot overcome 14% of the MVC;
- Load's highest values must not exceed 50% of the MVC and cannot overcome 70% of the MVC.

These limit values can be used as analysis criteria of the amplitude distribution probability curves for the relative strength in occupational tasks. One must consider the amplitude distribution probability level for an entire work day, and the limit should not be exceeded for over an hour in continuous work. If limit is exceeded, it must be exceptionally and for a 10 minutes maximum period.

These criteria can only be used for electromyographic records' analysis of a group of workers. The individual test results within workers can exceed these limits for several reasons, such as unfavorable operational modes selection, although workers group's overall workload is not excessive.

## 6 Data Logging

### NOTE

The following *biosignalsplux* features are demonstrated by using PLUX's *OpenSignals (r)evolution* software. Please review the software manual for more detailed information for general software use.

*biosignalsplux* devices with internal memory allow you to schedule and manage offline acquisitions which can be initialized and conducted without the requirement of a Bluetooth connection with your computer and *OpenSignals (r)evolution*.

The following devices are compatible with data logging features (scheduling, recording, and downloading recorded data):

- *biosignalsplux Professional*
- *biosignalsplux Force*
- *respiBAN Professional*

Internal memory can also be added additionally for all *biosignalsplux* devices. Please contact our support via e-mail at [support@plux.info](mailto:support@plux.info) if you'd like to add internal memory to your device to use all data logging features.

Devices with internal memory are displayed with an additional *SCHEDULE* button at the end of their device panels (see *Figure 89*). These devices are compatible with all data logging features.

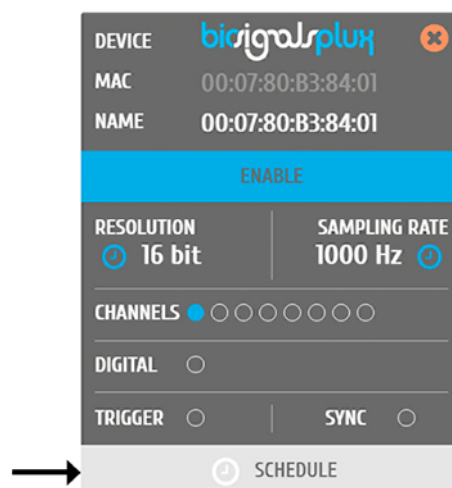


Figure 89: Data logging feature for devices with internal memory.

## 6.1 Scheduling Offline Acquisitions

### NOTE

Before scheduling offline acquisitions, we recommend setting up the device and channels first. To do so, configure your device to fit your sensors and channel configuration according to the instructions in chapter 3 *biosignalsplux Sensors* before entering the schedule panel.

Click on the *SCHEDULE* button of your device with internal memory in the device panel to access the scheduling panel to schedule and configure your offline acquisition (see *Figure 90*).

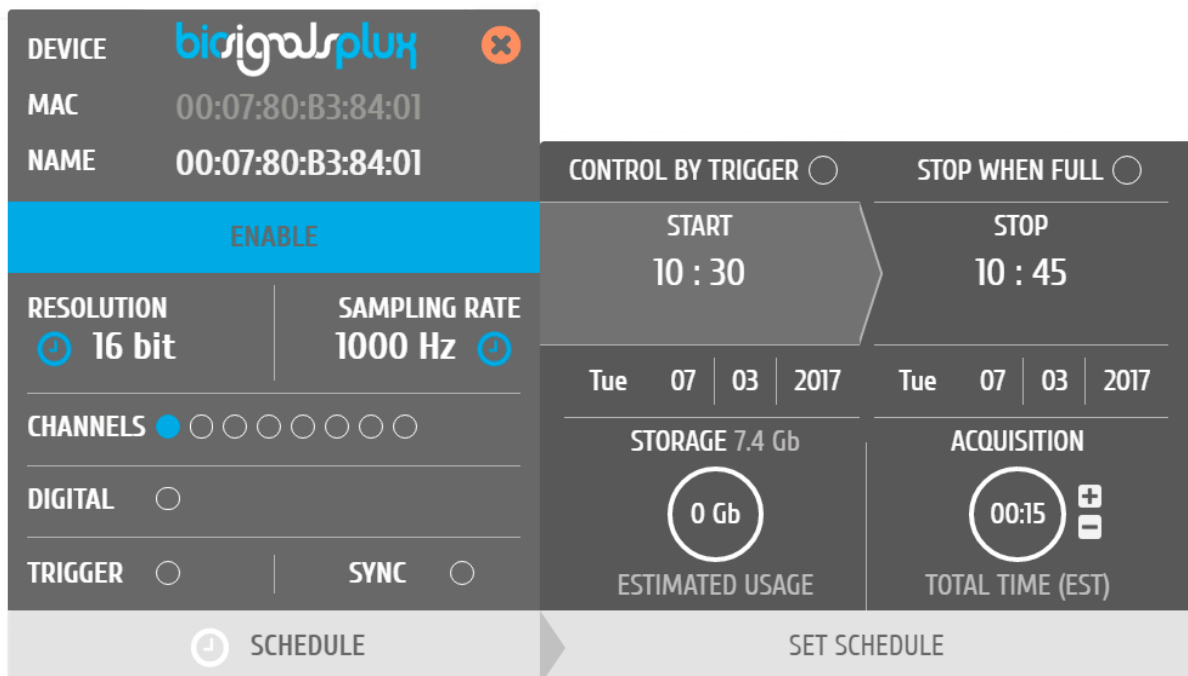


Figure 90: Scheduling panel.

The scheduling panel allows to configure your offline acquisition by defining the type of initiator for the start of your acquisition (timed or triggered), to stop the acquisition when the limits of the internal memory are reached (*STOP WHEN FULL*), to time acquisition at a specific time or duration (*STOP* and *ACQUISITION*), and displays information about the available free memory and the estimated memory usage of your scheduled acquisition.

### NOTE

The indications of the estimated end of the acquisitions are calculated estimations and might vary from real-life behaviour.

#### NOTE

It is recommended to fully charge your device's battery before using offline acquisitions as the acquisitions can be of longer period than the battery lifetime of your device, for example when using the *STOP WHEN FULL* option. The estimated end will not be reached if the battery runs out before.

#### NOTE

Your device does not have to be turned on before your scheduled acquisition starts, as it will automatically be turned on at the scheduled start-point.

To check if your device is acquiring data, check the LED information of your device:  
[http://biosignalsplux.com/datasheets/biosignalsplux\\_hub\\_Spec\\_Sheet.pdf](http://biosignalsplux.com/datasheets/biosignalsplux_hub_Spec_Sheet.pdf)

### 6.1.1 Control by Trigger

This option allows you to start your acquisition manually using one of the available trigger accessories for *biosignalsplux* (see 4.1.1 *Handheld Switch* or 4.1.2 *Foot Switch*). To activate this feature, click on the circle next to *CONTROL BY TRIGGER* and make sure that your trigger accessory is correctly connected to the digital port of your *biosignalsplux* device.

This feature is activated if this circle is filled blue and inactive if the circle is empty. Activating this feature will also remove every time information in the *START* and *STOP* fields.

To set up a fix duration of your offline acquisition, set up your preferred duration in the *ACQUISITION* field by using the '+' and '-' buttons. The acquisition will then stop when the duration has been passed, with the duration starting at the point where the trigger signal has been given.

Click on the *STOP WHEN FULL* option to stop the acquisition only when there is no memory left on your device. Read the following section for more information about this option.

### 6.1.2 Stop When Full

The *STOP WHEN FULL* option will stop your offline acquisition when the internal memory of your device has run out of available memory. This function can both used with trigger-based or timer-based initiated offline acquisitions. If a fixed time has been selected for the start of the acquisition, the estimated end of the acquisition will be calculated based on the available free memory and will be displayed in the *STOP* field of the scheduling panel (see *Figure 91*).

The scheduling panel is divided into several sections:

- Device Information:**
  - DEVICE: biosignalsplux
  - MAC: 00:07:80:B3:84:01
  - NAME: 00:07:80:B3:84:01
- Controls:**
  - ENABLE: (Blue button)
  - RESOLUTION: 16 bit
  - SAMPLING RATE: 1000 Hz
  - CHANNELS: 1 selected (blue dot), 6 others (grey dots)
  - DIGITAL: (Off)
  - TRIGGER: (Off)
  - SYNC: (Off)
- Acquisition Settings:**
  - CONTROL BY TRIGGER: (Off)
  - STOP WHEN FULL: (On)
  - START: 11 : 00
  - STOP: 20 : 34 ESTIMATED
  - DATE: Tue 07 | 03 | 2017
  - STORAGE: 7.4 Gb
  - ACQUISITION: 441:34
  - ESTIMATED USAGE: 7.4 Gb
  - TOTAL TIME (EST): 441:34
- Buttons:**
  - SCHEDULE (Clock icon)
  - SET SCHEDULE

Figure 91: Scheduling panel displaying the estimated end of the acquisition.

### 6.1.3 Scheduling Start & End Times

The time schedule interface includes:

- Calendar:** A calendar for March 2017. The 7th is highlighted in blue.
- Time Picker:**
  - Time: 10:15
  - Hour: (Slider)
  - Minute: (Slider)
- Buttons:**
  - Now
  - Done

Figure 92: Time schedule for start and end points for offline acquisitions.

Alternatively, you can also set up a fix duration for your acquisition instead of configuring an end time. To do so, set up your preferred duration in the *ACQUISITION* field by using the '+' and '-' buttons. The acquisition will then stop when the duration has been passed, with the duration starting at the scheduled time configured in the *START* field.

#### 6.1.4 Setting & Clearing Acquisition Schedules

If you've finished configuring your device and your offline acquisition, click on the *SET SCHEDULE* button at the bottom of the scheduling panel to transmit all the configurations to your device. The transmission and configuration has been successful if the button at the bottom of your device panel in *OpenSignals (r)evolution* has changed from *SCHEDULE* to *SCHEDULED* followed by the day and time when the acquisition has been configured to start (non-triggered acquisitions only) (see *Figure 93*; here: Tuesday 19:00h).

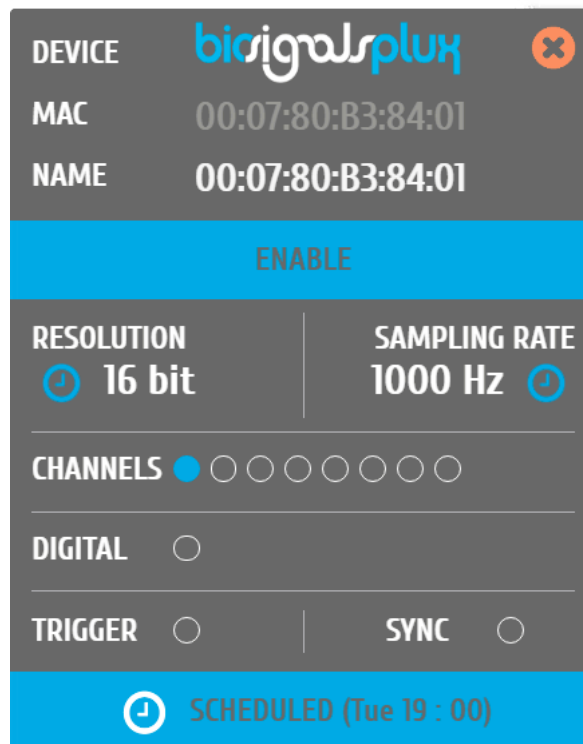


Figure 93: Device panel with a scheduled acquisition.

To clear a scheduled acquisition, click on the *SCHEDULED* button and click on the *CLEAR SCHEDULE* of the scheduling panel. The scheduled offline acquisition will be removed and your device can now be configured for a new offline acquisition.

## 6.2 Downloading Offline Acquired Data

After your offline acquisition has finished, you can download the recording by clicking on the download data button in the *OpenSignals (r)evolution* main screen:

- ④ Download an acquisition from the memory card

The offline can be downloaded from your device's internal memory within *OpenSignals (r)evolution* via Bluetooth or via the *fast USB data transfer* cable (additional accessory). The following sections provide the instructions on how to download data using both methods.

### 6.2.1 Download via Bluetooth

Make sure your *biosignalsplux* is turned on and click on the download button in the *OpenSignals (r)evolution* main screen to access the download panel. In this panel, all the available offline acquisitions which are available for download from your device's internal memory are listed.

Each offline acquisition creates its own file where the acquired data is stored. In the download panel, the files are listed with their file name (*FILE*) their start time (*START*) and their entire duration (*DURATION*). Click on the indicated arrow in a file's row to download the selected file (see *Figure 94*) or click on the arrow in the top row of the downloading panel to download all available files. The downloaded files will be stored on your desktop.

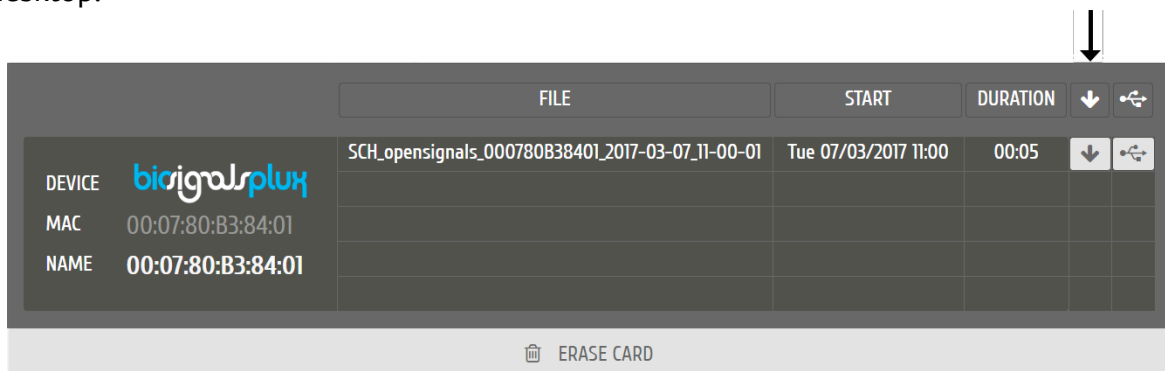


Figure 94: Downloading offline acquired data via Bluetooth.

#### NOTE

The time needed to download an acquisition file depends on the size of the file and, therefore, on the duration of your scheduled acquisition. The download process might need several minutes to end. Do not use nor turn off your device when *OpenSignals (r)evolution* is downloading data, as doing so might make the downloaded file unreadable.



## 6.2.2 Download via Fast USB Data Transfer Cable

### NOTE

This method requires accessories which have to be bought additionally (in some kits). These accessories are available in our store.

biosignalsplux USB Adapter & fast USB data transfer cable:

<https://store.plux.info/biosignalsplux-accessories/371-fast-usb-data-transfer-cable-for-biosignalsplux-820201514.html>

Make sure your *biosignalsplux* is turned on and connected to your computer via USB with the *biosignalsplux USB adapter*. Connect the *USB adapter* to the reference port of your *biosignalsplux* (see 2.3.3 Reference) and click on the download button in the *OpenSignals (r)evolution* main screen to access the download panel. In this panel, all the available offline acquisitions which are available for download from your device's internal memory are listed.

Each offline acquisition creates its own file where the acquired data is stored. In the download panel, the files are listed with their file name (*FILE*) their start time (*START*) and their entire duration (*DURATION*). Click on the indicated USB symbol in a file's row to download the selected file (see Figure 95) or click on the USB symbol in the top row of the downloading panel to download all available files. The downloaded files will be stored on your desktop.

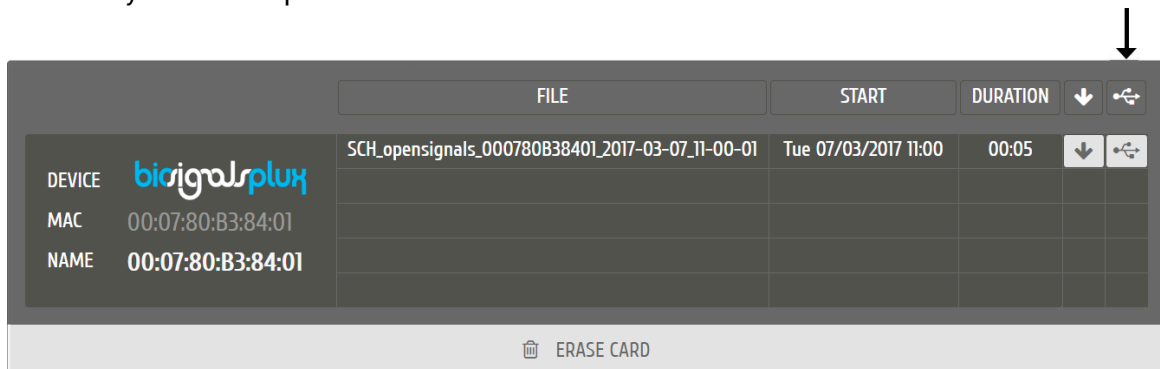


Figure 95: Downloading offline acquired data via USB.

### NOTE

The time needed to download an acquisition file depends on the size of the file and, therefore, on the duration of your scheduled acquisition. The download process might need several minutes to end.

Do not use nor turn off your device when *OpenSignals (r)evolution* is downloading data, as doing so might make the downloaded file unreadable.



### 6.2.3 Deleting Offline Acquired Data

#### NOTE

Deleted files **cannot be restored**. Make sure you have downloaded all the needed files **before** deleting or erasing the internal memory of your device to prevent accidental data loss.

To delete all files stored in the internal memory of your device, click on the *ERASE CARD* button at the bottom of the download panel.

## 7 Bluetooth Setup

When connecting the device, you first need to enable Bluetooth on your computer or need to plugin the Bluetooth dongle to your USB port, if Bluetooth is not built in or reliable for your computer. Follow the instructions for your operating system that are displayed on the following pages to connect your *biosignalsplux* to your computer.

### 7.1 Windows 7

To connect your device to your computer via Bluetooth, click on the start button at the right lower part of the Windows taskbar and click on *Control Panel* to access the control panel of your computer.

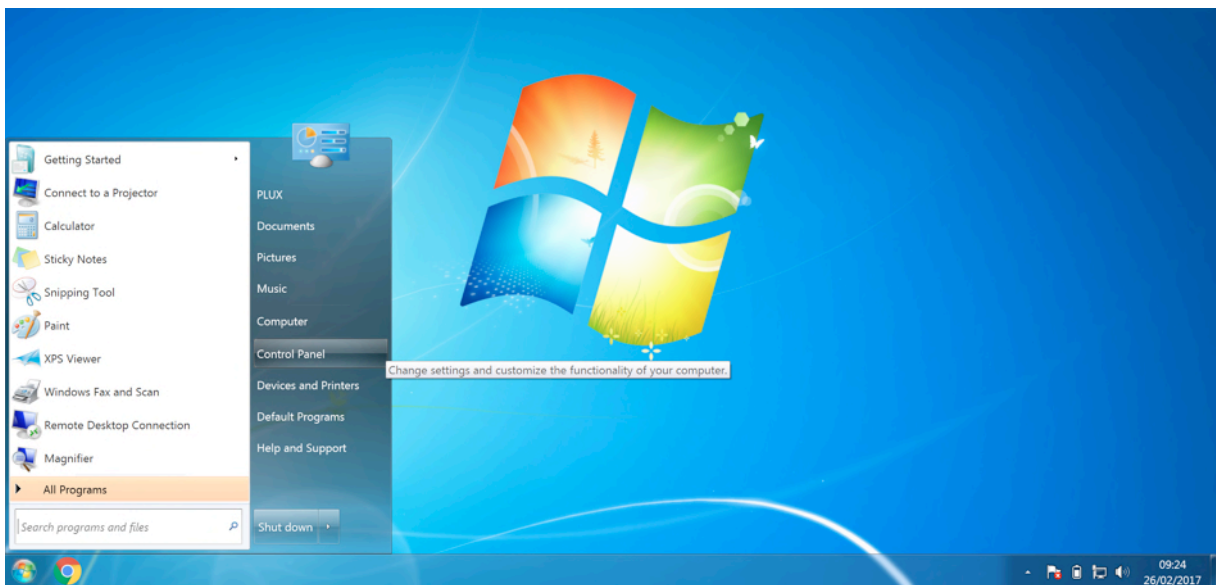


Figure 96: Access the Windows 7 control panel.

In the control panel, select the *Add a device* option in the *Hardware and Sound* section to add your device.

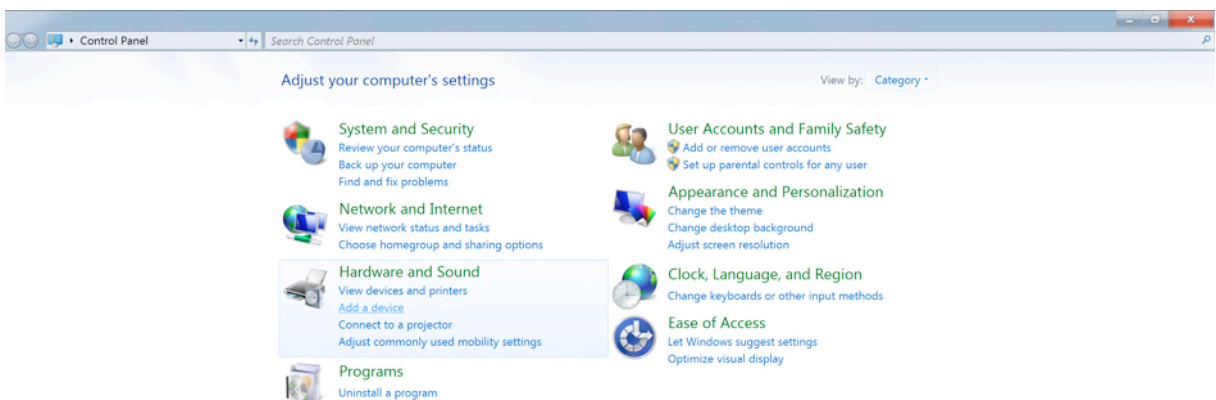


Figure 97: Select Add a device in the Hardware and Sound section.

At this point, turn on your *biosignalsplux* (if not done before) and wait until it appears in the list available devices. When your device has been found (here: *biosignalsplux*), click on the device and click on *Next* at the lower right corner of the *Add a device* window.

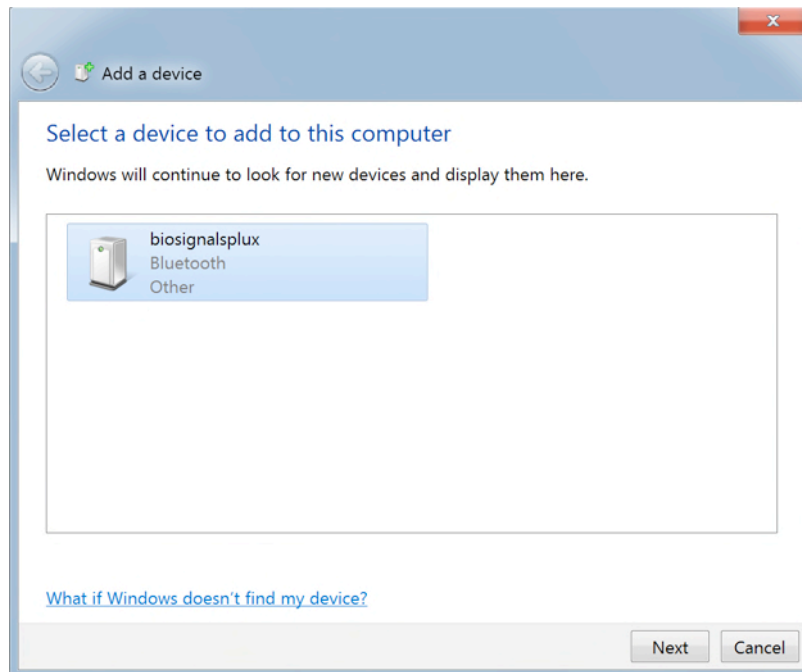


Figure 98: Select your device to add it to your computer.

Click on *Enter the device's pairing code* and click on *Next* at the lower right corner of the window to proceed.

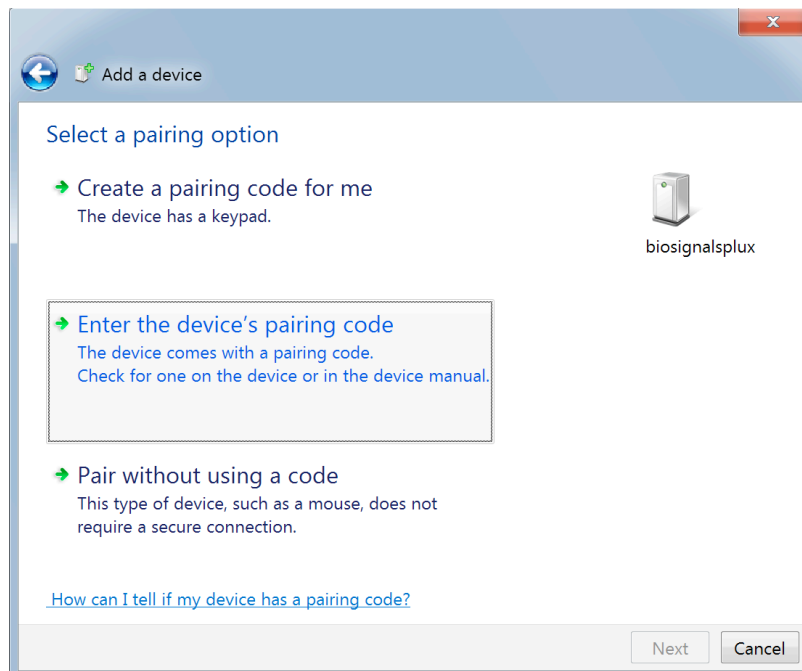


Figure 99: Select Enter the device's pairing code.

For *biosignalsplux* devices enter 123 and click on *Next* to connect to your device. For *BITalino* devices enter 1234 and click on *Next* to connect to your device.

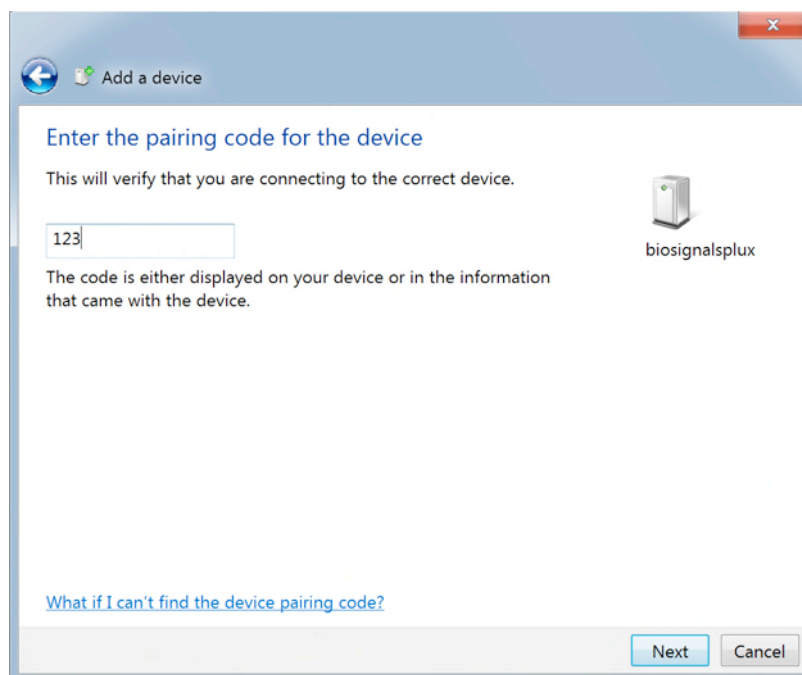


Figure 100: Enter the pairing code to connect to your device.

If Windows confirms that your device has been successfully added to your computer, the connection has been successfully established.

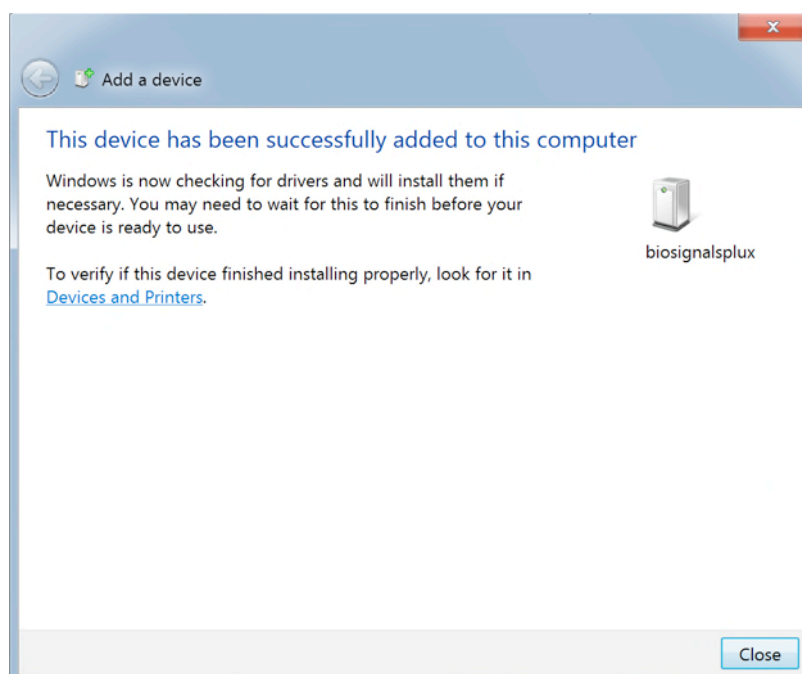


Figure 101: Windows confirmation if the device has been successfully added.

## 7.2 Windows 8

To connect your *biosignalsplux* device to your computer via Bluetooth, click on the start button at the right lower part of the Windows taskbar, click on the triangle symbol and click on the Bluetooth icon to open the Bluetooth settings panel.



Figure 102: Access to the Bluetooth settings panel in Windows 8.

At this point, turn on your *biosignalsplux* (if not done before) and wait until it appears in the list of Bluetooth devices. When your *biosignalsplux* device has been found, click on the device and click on *Pair* to connect to your device.

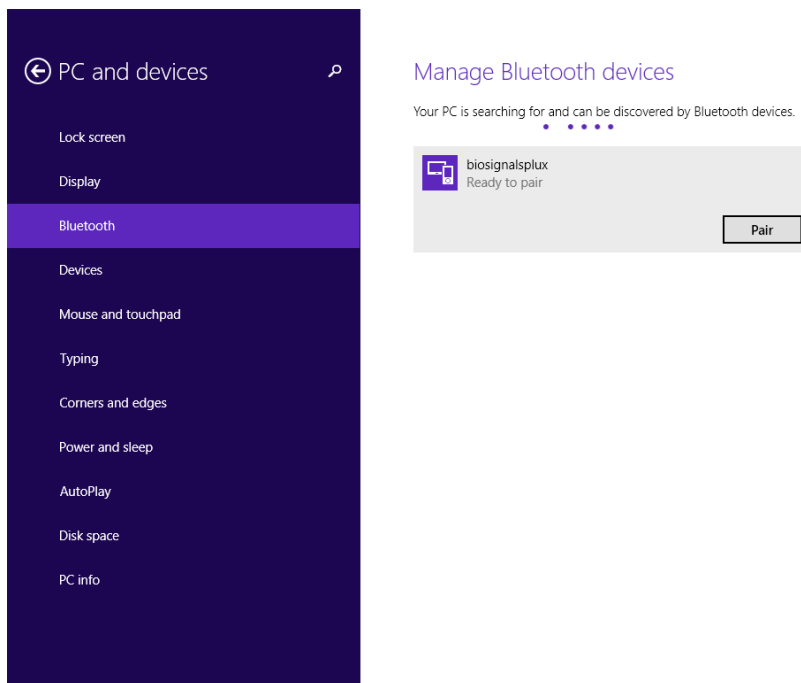


Figure 103: Bluetooth settings panel.

Windows will now try to connect to your device and pop up a window requesting you to enter the passcode (pin) of your device. Enter 123 and click on *Next* to connect to *biosignalsplux*.

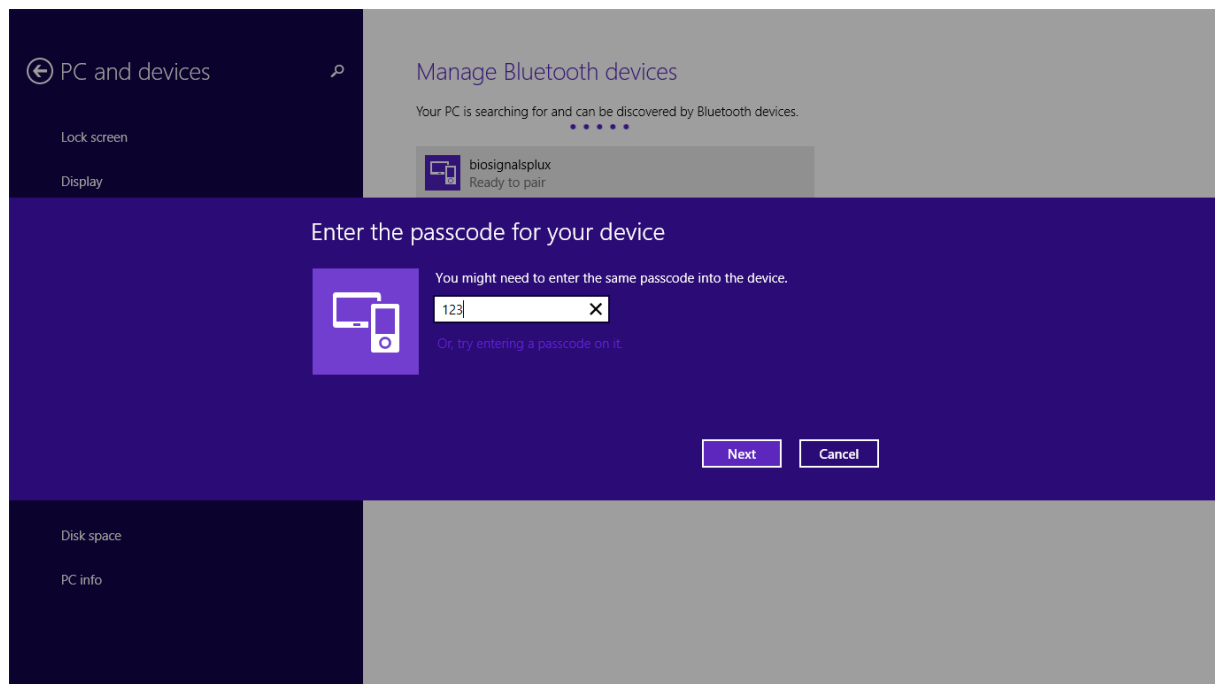


Figure 104: Requesting biosignalsplux' passcode (123).

If *Connected* is displayed under the name of your *biosignalsplux* device in the Bluetooth settings panel, the connection has been successfully established.



## 7.3 Windows 10

To connect your *biosignalsplux* device to your computer via Bluetooth, click on the start button at the left lower corner in Windows 10 to open the start menu. Click on the gear symbol to open the settings panel of your operating system as can be seen below.

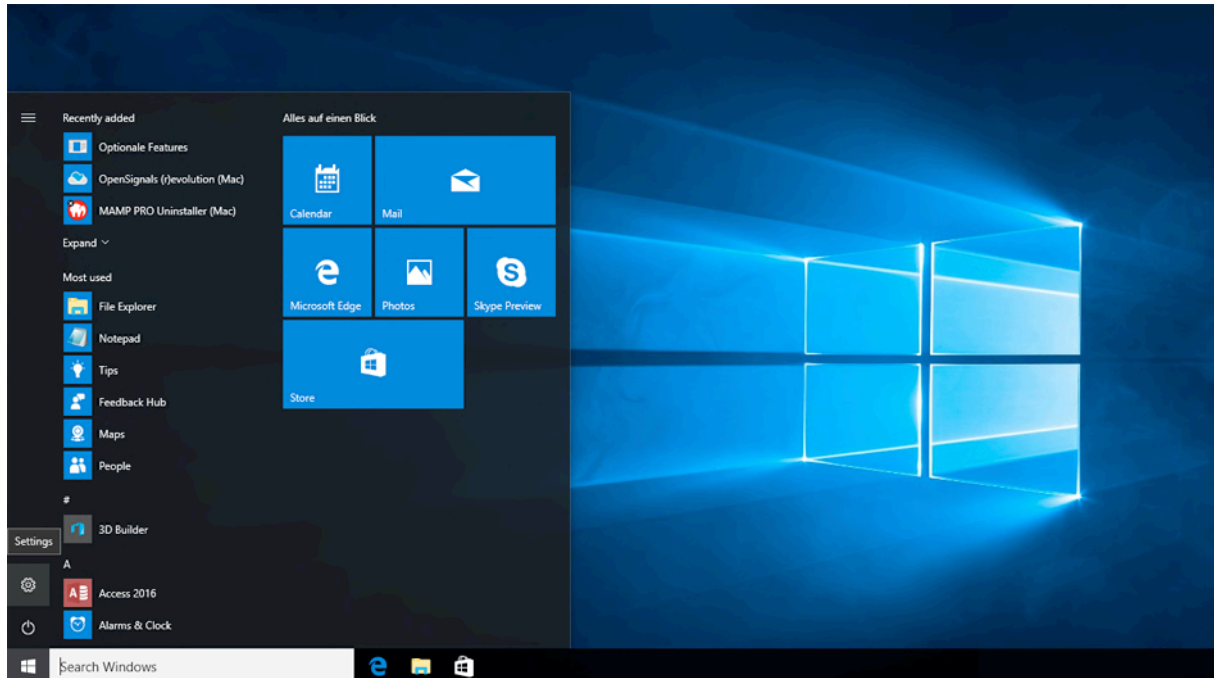


Figure 105: Access to the settings panel in Windows 10.

In the settings panel, click on the *Devices Bluetooth, printers, mouse* field to open the device configurations of your system.

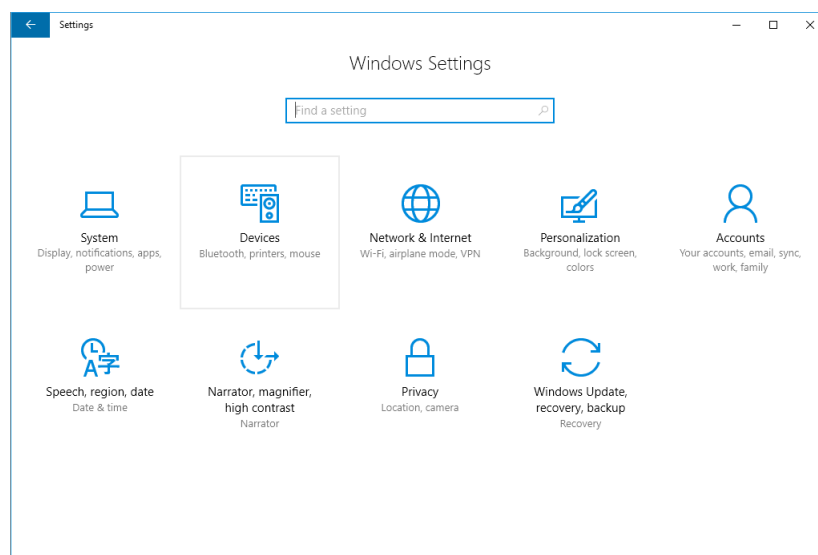


Figure 106: Windows 10 settings panel.

Select *Bluetooth* from the list which is displayed on the left side of your settings window. Note, that in some versions the Bluetooth option might not be available and that Bluetooth devices might be listed under *Other devices* as seen in Figure 107.

At this point, turn on your *biosignalsplux* (if not done before) and wait until it appears in the list of Bluetooth devices. When your *biosignalsplux* device has been found, click on the device and click on *Ready to pair* to connect to your device.

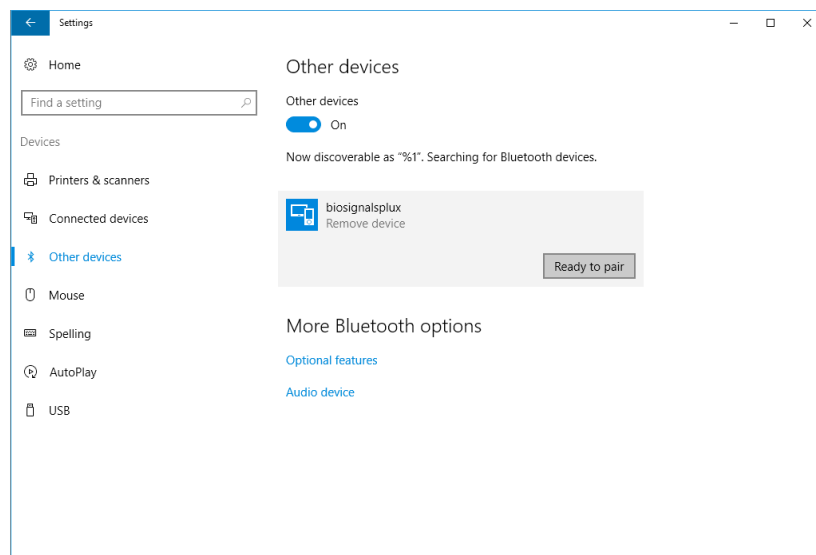


Figure 107: Bluetooth settings panel.

Windows will now try to connect to your device and pop up a window requesting you to enter the passcode (pin) of your device. Enter 123 and click on next to connect to *biosignalsplux*.

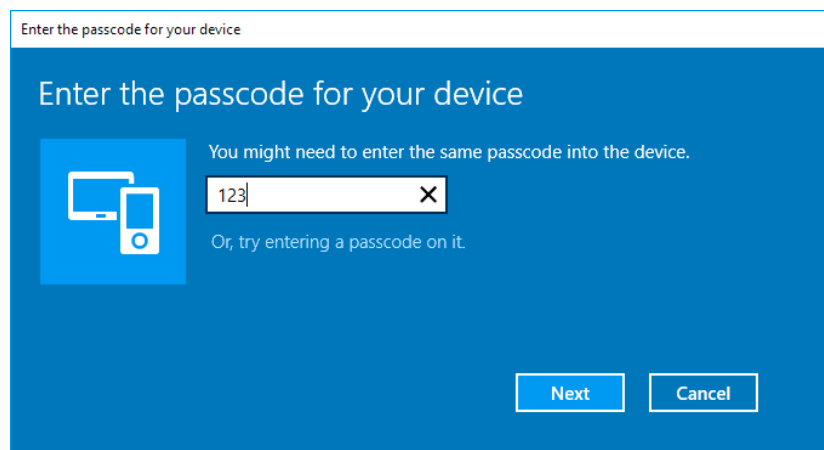


Figure 108: Requesting passcode (123).

If *Pair* is displayed under the name of your *biosignalsplux* device in the Bluetooth settings panel, the connection has been successfully established.

## 7.4 Linux

Ubuntu offers two options on how to connect your devices via Bluetooth to your computer. The first option allows you to connect the device via Ubuntu's system settings and the graphical interface. The second option allows you to connect the device via the terminal. However, the second option is recommended for advanced users only.

### 7.4.1 Connecting via System Settings

To connect your device to your computer via Bluetooth, click on the wheel in the top right corner of the display and click on *System Settings*.. to access the settings panel of your computer.



*Figure 109: Access the system settings in Ubuntu.*

In the settings panel, click on the Bluetooth logo to access the Bluetooth settings panel.

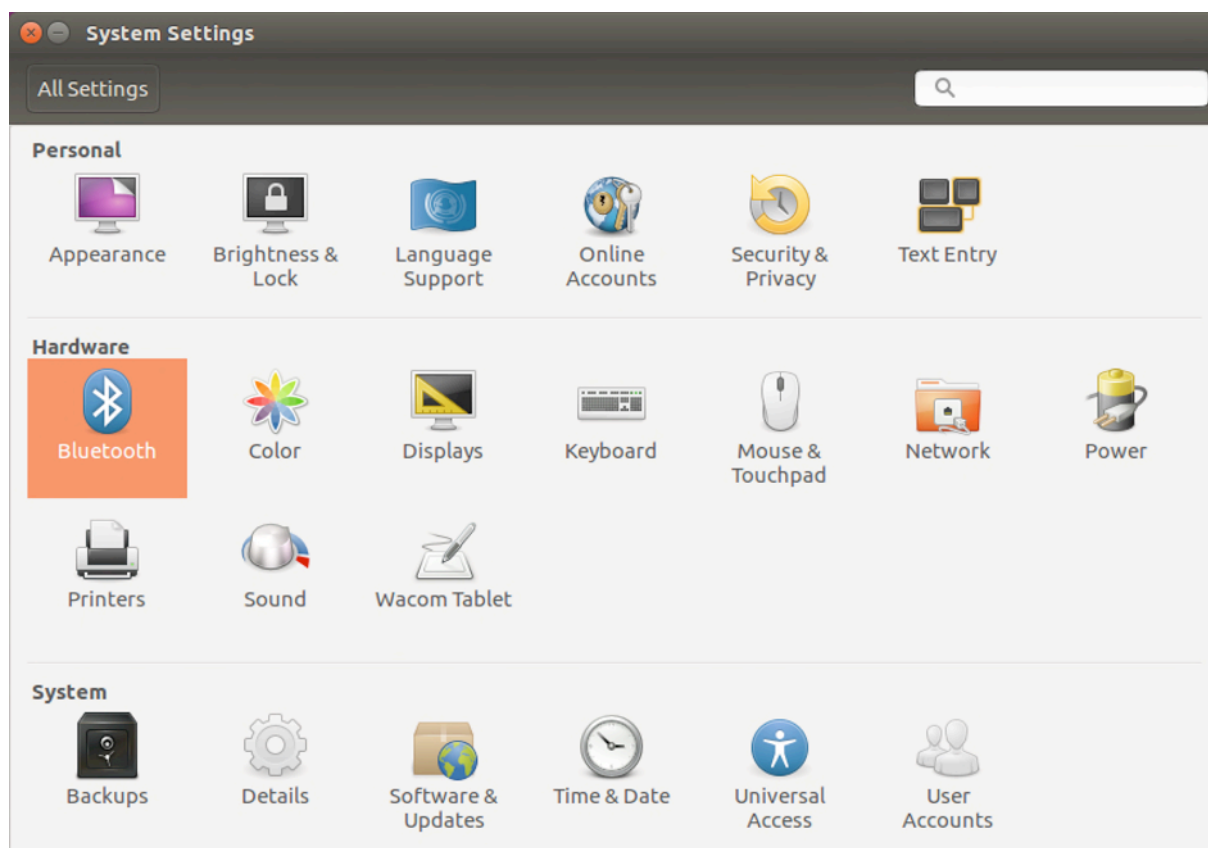


Figure 110: Click on the Bluetooth logo to access the Bluetooth settings.

At this point, turn on your *biosignalsplux* (if not done before) and wait until it appears in the list available devices. When your device has been found (here: *biosignalsplux*), it will be listed in the *Device Search* window. Click on the device and select *PIN options...* to enter the device's PIN to proceed.

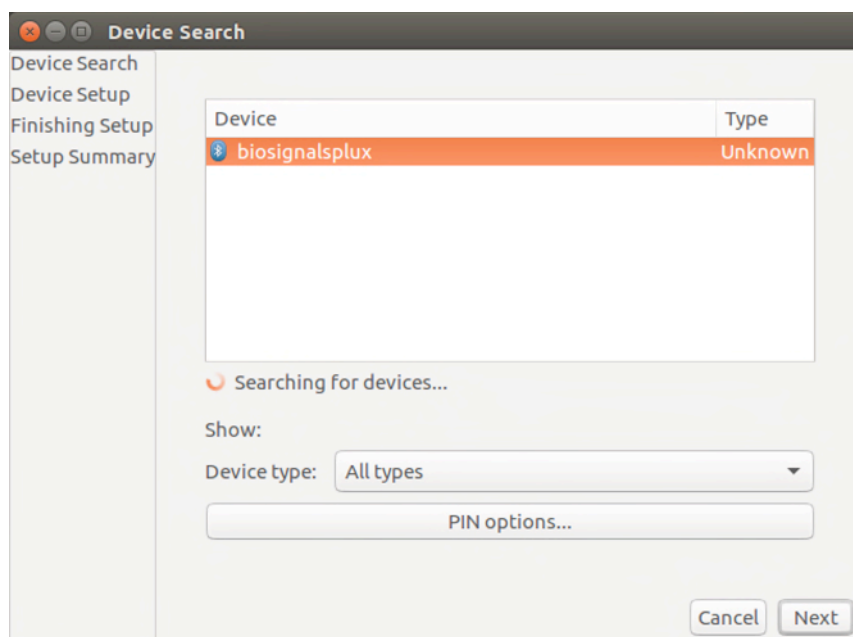


Figure 111: Select your device to add it to your computer.

In the new *PIN Options* window click on *Custom PIN* and enter the device's PIN to connect to your device. For *biosignalsplux* devices enter 123 and click on *Next* to connect to your device.

#### NOTE

If the *Custom PIN* option is not available in this window, follow up with the instructions in *Connecting via Terminal* to connect your device to your computer using the terminal instead of proceeding with the configuration via the system settings.

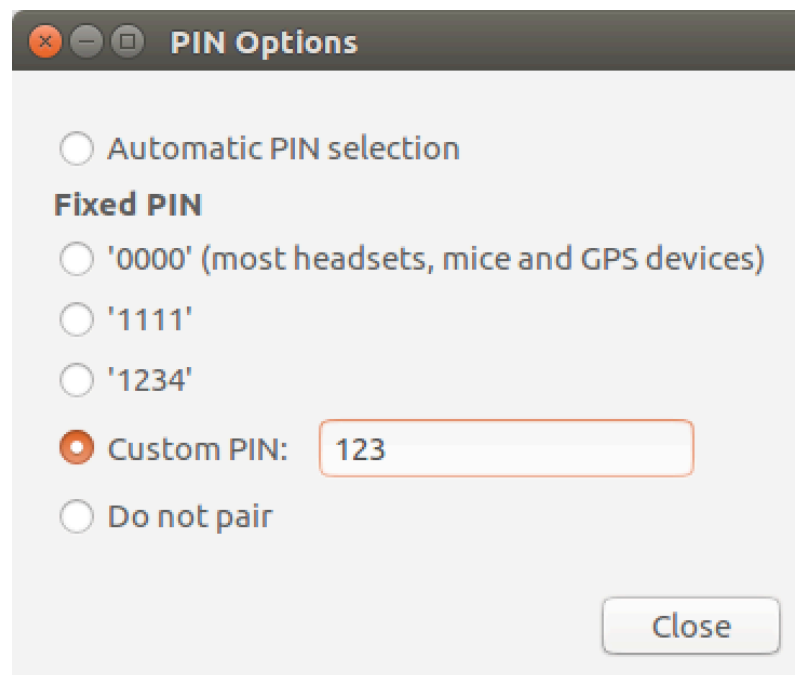


Figure 112: Enter the device's pin to pair.

Click on *Close* to close this window and click on *Next* on the *Device Search* window to connect to your device.

Click on your device in the *Devices* list. If paired is confirmed (*Paired Yes*) your device has been successfully connected to your computer<sup>8</sup>.

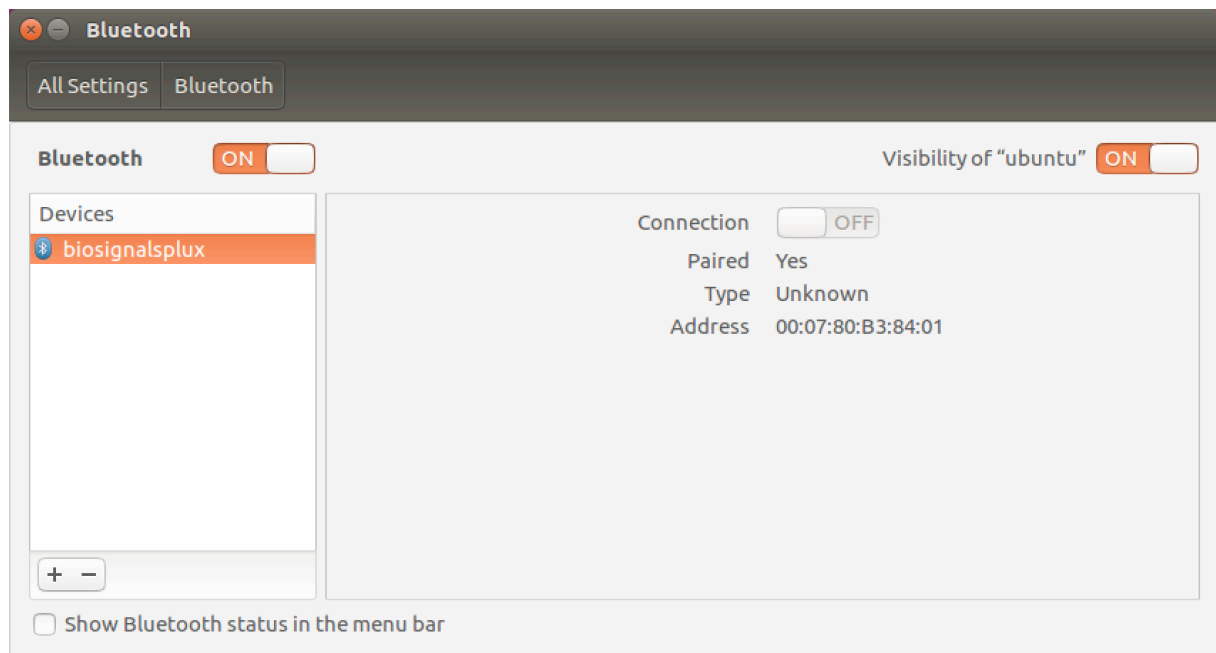


Figure 113: Successfully paired biosignalsplux.

<sup>8</sup> Do not worry if the connection is set off. It will automatically switch to on when connecting to your device using *OpenSignals* or other custom software for *biosignalsplux*.

## 7.4.2 Connecting via Terminal

### NOTE

Using the terminal may harm your computer if it is not done correctly. Therefore, this method is recommended for advanced users only and following this method is done at your own risk.

To connect your device to your computer via Bluetooth, click on the *Unity Dash* logo in the toolbar on the left to your desktop open the search function. In the search bar, enter terminal (or Terminal) and click on the terminal logo to open the *Terminal*.

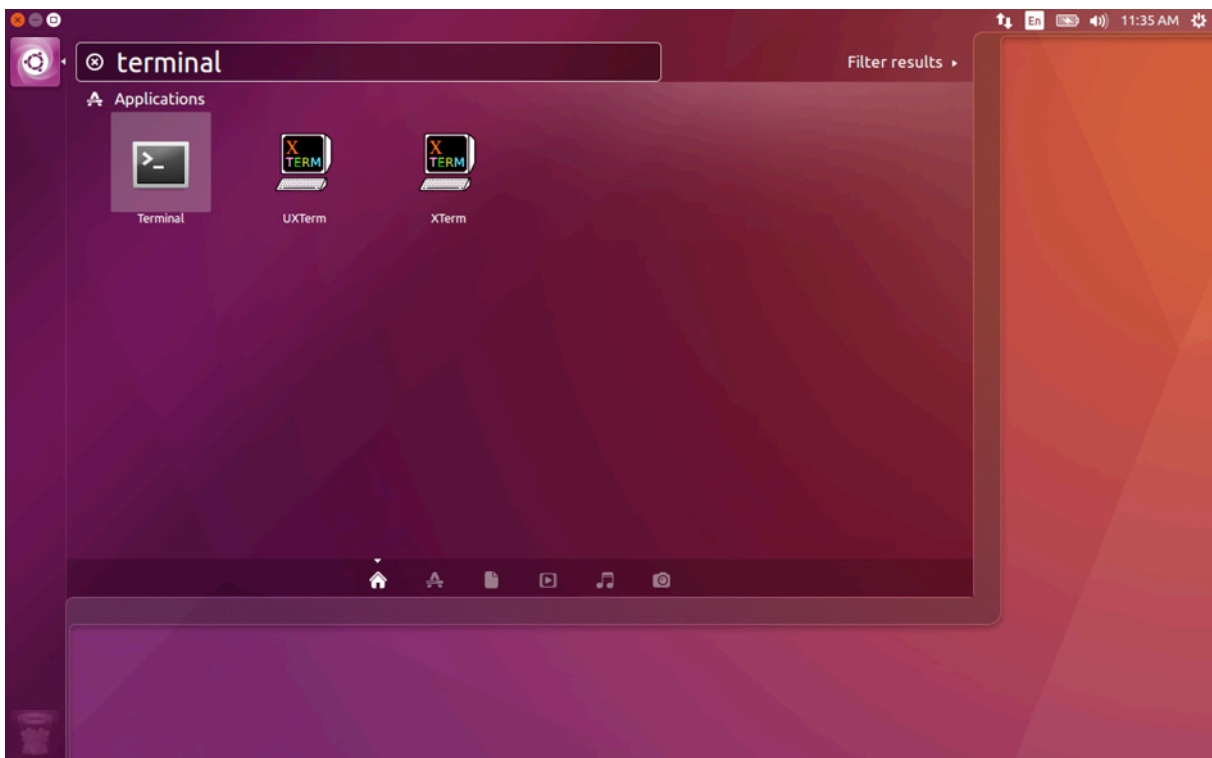


Figure 114: Access the terminal using the search function in Ubuntu.

Enter *bluetoothctl* into the terminal window (without the \$). Terminal should answer to this command with a line displaying the MAC address of your internal Bluetooth adapter. The response should be similar to this (with AA:BB:CC:DD:EE:FF being replaced with your MAC address):

```
$ bluetoothctl
[NEW] Controller AA:BB:CC:DD:EE:FF ubuntu [default]
[bluetooth]#
```

Next, enter turn on your internal Bluetooth module on (if not done before) by entering *power on* into the Bluetooth prompt line. The response should be similar to this (again, with AA:BB:CC:DD:EE:FF being replaced with your MAC address):

```
[bluetooth]# power on
Changing power on succeeded
[CHG] Controller AA:BB:CC:DD:EE:FF Powered: yes
```

Next, it is needed to turn on a Bluetooth agent. The Bluetooth agents manages the transmission of pin codes (or pairing codes) between devices and is needed here to send the pairing code to the device you want to connect. To do this, enter *agent on*. The terminal response should be similar to this:

```
[bluetooth]# agent on
Agent registered
```

Set up the *default-agent* to proceed with the pairing process.

```
[bluetooth]# default-agent
Default agent request successful
```

At this point, turn on your device (if not done before) and enter *scan on* into the terminal to search for available Bluetooth devices and wait until your device's MAC address appears in the list (here: biosignalsplux, 00:07:80:B3:84:01). Your device's MAC address can be found at the back of the device.

```
[bluetooth]# scan on
Discovery started
[CHG] Controller AA:BB:CC:DD:EE:FF Powered: yes
[NEW] Device 00:07:80:B3:84:01 biosignalsplux
```

If your device is listed, enter *pair* followed by the MAC address of your device to start the pairing process which will be respond with requesting the PIN code of your device. For *biosignalsplux* devices enter 123 and click on *Next* to connect to your device. For *BITalino devices* enter 1234 and click on *Next* to connect to your device. The result should be similar to this:

```
[bluetooth]# pair 00:07:80:B3:84:01
Attempting to pair with 00:07:80:B3:84:01
Request PIN code
[agent] Enter PIN code: 123
[CHG] Device 00:07:80:B3:84:01 Connected: yes
[CHG] Device 00:07:80:B3:84:01 Modalias: bluetooth
[CHG] Device 00:07:80:B3:84:01 UUIDs: (device specific ID)
[CHG] Device 00:07:80:B3:84:01 UUIDs: (device specific ID)
[CHG] Device 00:07:80:B3:84:01 Paired: yes
Pairing successful
[biosignalsplux]
```



If the terminal outputs *Pairing successful* your device has been successfully paired to your computer.

The entire text of your terminal should now be similar to the following:

```
$ bluetoothctl
[NEW] Controller AA:BB:CC:DD:EE:FF ubuntu [default]
[bluetooth]#
[bluetooth]# power on
Changing power on succeeded
[CHG] Controller AA:BB:CC:DD:EE:FF Powered: yes
[bluetooth]# agent on
Agent registered
[bluetooth]# default-agent
Default agent request successful
[bluetooth]# default-agent
Default agent request successful
Discovery started
[CHG] Controller AA:BB:CC:DD:EE:FF Powered: yes
[NEW] Device 00:07:80:B3:84:01 biosignalsplux
[bluetooth]# pair 00:07:80:B3:84:01
Attempting to pair with 00:07:80:B3:84:01
Request PIN code
[agent] Enter PIN code: 123
[CHG] Device 00:07:80:B3:84:01 Connected: yes
[CHG] Device 00:07:80:B3:84:01 Modalias: bluetooth
[CHG] Device 00:07:80:B3:84:01 UUIDs: (device specific ID)
[CHG] Device 00:07:80:B3:84:01 UUIDs: (device specific ID)
[CHG] Device 00:07:80:B3:84:01 Paired: yes
Pairing successful
[biosignalsplux]
```

## 7.5 Mac OS X

To connect your *biosignalsplux* device to your computer via Bluetooth, click on the Apple symbol at the top left corner of your display and select *System Preferences*...

In the system preferences window click on the Bluetooth symbol to open the Bluetooth settings.

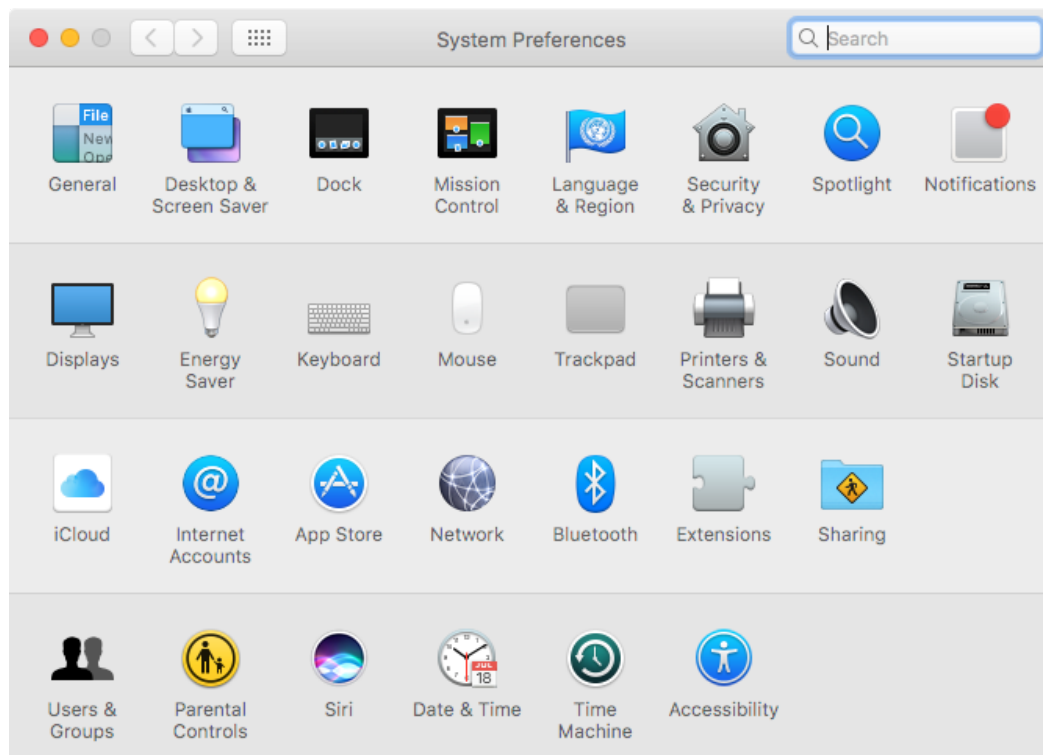


Figure 115: Mac OS X system preferences window.

At this point, turn on your *biosignalsplux* (if not done before) and wait until it appears in the list of Bluetooth devices. When your *biosignalsplux* device has been found, click on the device and click on *Pair* to connect to your device.

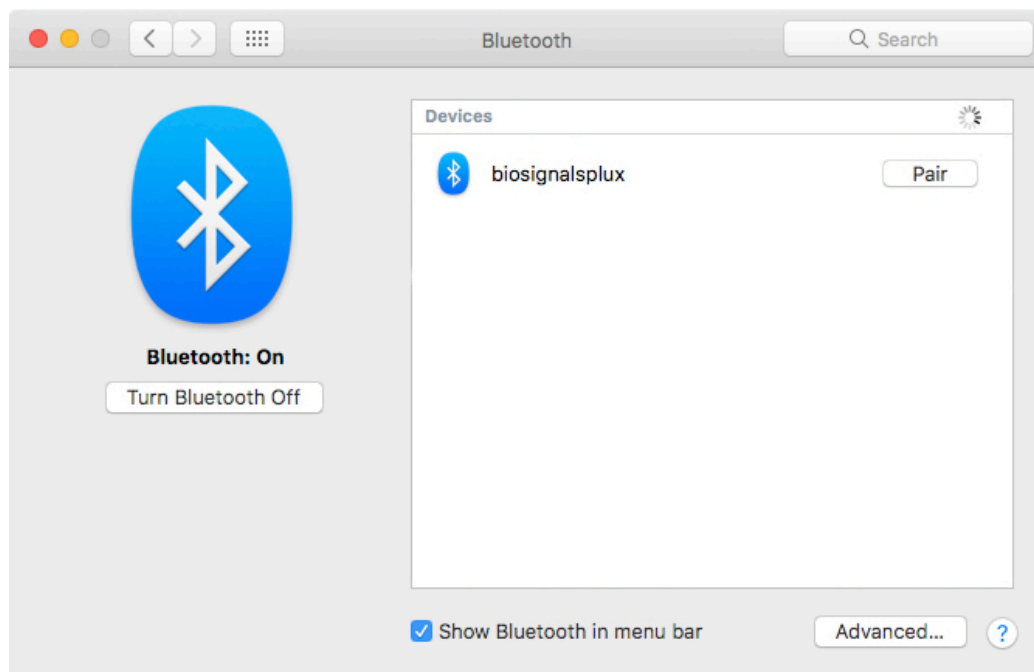


Figure 116: Click on Pair to connect to the biosignalsplux.

An error will occur indicating that the connection could not be established due to a mismatching passkey. Click on *Options...* to enter the passkey (pairing code).

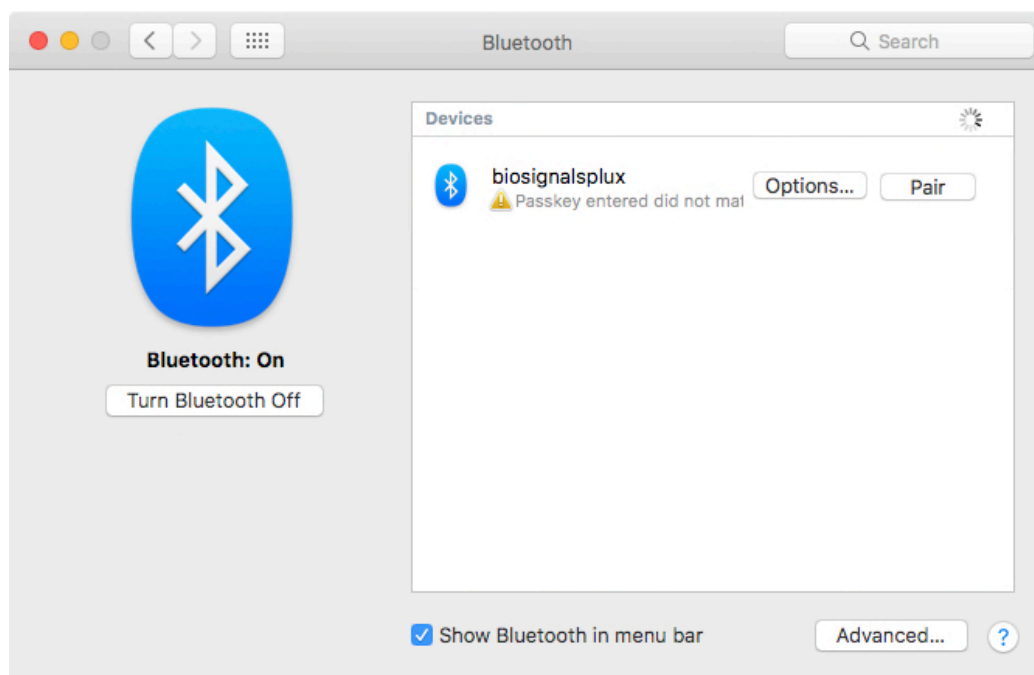


Figure 117: Click on Options... to enter the passkey.

Mac OS X will now try to connect to your device and pop up a window requesting you to enter the passcode (pin) of your device. Enter 123 and click on *Pair* to connect to *biosignalsplux*.

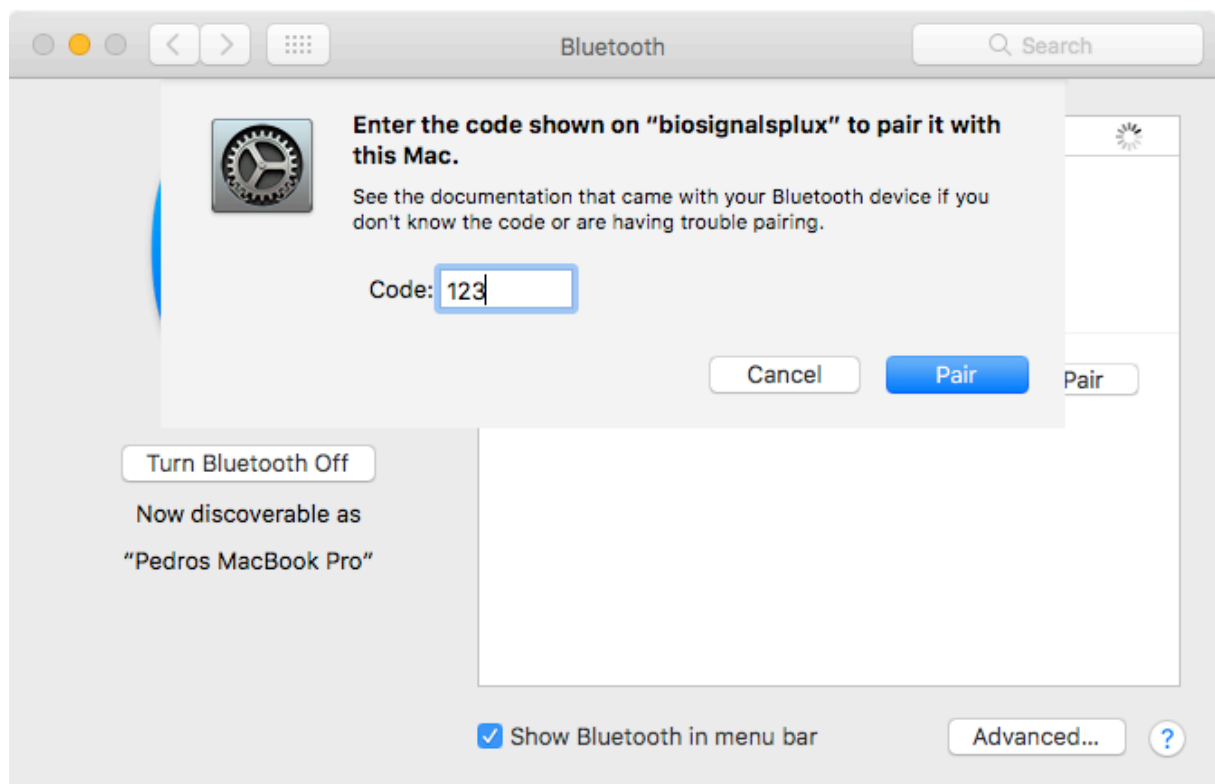


Figure 118: Enter the pairing code

If *Connected* is displayed under the name of your *biosignalsplux* device in the Bluetooth settings panel, the connection has been successfully established.

## 8 Firmware Updates & Upgrades

*biosignalsplux* firmware updates are not done automatically. We recommend to frequently check if newer firmware versions are available and to upgrade or update the firmware on your device when newer versions are available to ensure full functionality and compatibility with all *biosignalsplux* sensors and accessories.

Updating the *biosignalsplux* firmware lets you also take advantage of all the newest recording resolutions and offline scheduling features.

Check the following website to see if newer firmware versions are available, and download and extract all the required tools to update or upgrade your firmware:

<http://biosignalsplux.com/index.php/en/software/utilities>

### NOTE

*biosignalsplux* devices can be used on Windows, Linux and Mac OSX operating systems. However, at the time being, the firmware update software does only run on Windows operating system.

For Mac OS X and Linux users, the firmware update software can be used in virtual machines running a compatible Windows version (Windows 7 or newer).

### 8.1 Checking Firmware Version

Before updating the firmware of your *biosignalsplux* device, it is recommended to check the current device's firmware version to see whether a firmware update is required or not.

To do so, make sure that your device is charged and turned on (LED must blink green). If you haven't connected your device to your computer via Bluetooth before, connect your device following the instructions in *Bluetooth Setup* before following the next steps.

Open the *Updater.exe* you've just downloaded and extracted. A new window will appear. Click on the *Find Devices* button and wait for your MAC address to appear in the *Device Mac Address Field*.

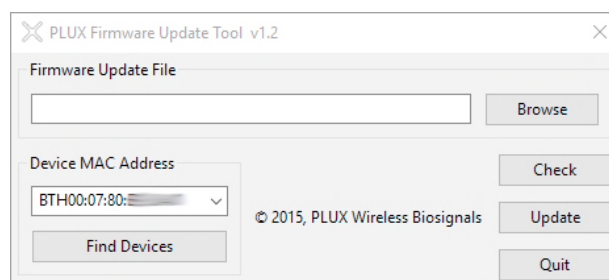


Figure 119: PLUX firmware update tool has found one *biosignalsplux*.

Check if the MAC address that is listed in the dialog matches the MAC address of the *biosignalsplux* device you want to update or upgrade. The MAC address of the device is placed on its back. Click on the *Check* button.

The firmware update software will check the current version of the *biosignalsplux* and display it in the dialog field.

## 8.2 Updating or Upgrading Firmware

If your device is running on an older firmware<sup>9</sup> it is recommended to update or upgrade the firmware for compatibility reasons with new features and to ensure that your device works properly with the newest version of the *OpenSignals (r)evolution* software.

To do so, make sure that your device is charged and turned on (LED must blink green). If you haven't connected your device to your computer via Bluetooth before, connect your device following the instructions in *Bluetooth Setup* before following the next steps.

Open the *Updater.exe* you've downloaded and extracted. A new window will appear. Click on the *Find Devices* button and wait for your MAC address to appear in the dialog bellows. Check if the MAC address that is listed in the dialog matches the MAC address of the *biosignalsplux* device you want to update or upgrade. The MAC address of the device is placed on its back.

Click on *Browse* and browse the folder where the firmware .ENC file from the downloaded package is placed and select the .ENC file. The firmware updater should now be similar to the firmware updater in and click the *Update* button.

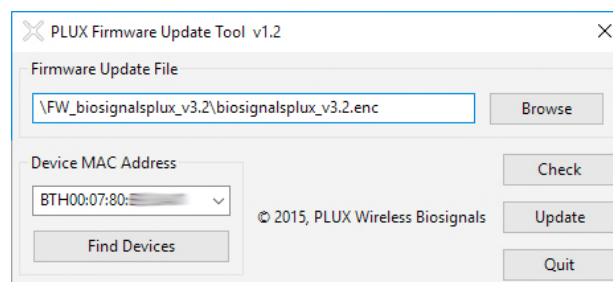


Figure 120: Firmware update tool is ready to update the firmware.

*biosignalsplux* will turn itself off two times during the firmware update or upgrade. Wait for the *biosignalsplux* to turn itself on again after the first time (this may take some seconds). The *biosignalsplux* firmware will now be installed on the *biosignalsplux* and the device will automatically turn itself off for the second time after the installation is finished. This time, check for the indications of the update software, and, if no different indications are given, turn your device back on and confirm the dialog of the update software by clicking on the *OK* button.

---

<sup>9</sup> or if you need to upload another firmware to run with specific sensors (e.g. beta versions of new sensors)

When the firmware update/upgrade has finished, a dialog will pop up displaying the old and the new version of the *biosignalsplux* firmware. new firmware was successfully installed if the version of the new firmware matches your selected .ENC file and if it is superior to the version of the displayed old firmware.

## 9 Software & APIs

### 9.1 OpenSignals (r)evolution

OpenSignals is our easy-to-use, versatile, and scalable software for real-time biosignals visualization, capable of direct interaction with all PLUX devices.

Core functionality includes sensor data acquisition from multiple channels and devices, data visualization and recording, as well as loading of pre-recorded signals. OpenSignals is also a Python-powered web-based software framework, targeted at rapid application development; a bare bone code base is available on [GitHub](https://github.com/biosignalsplux)

In addition, OpenSignals has a suite of data analysis add-ons to create reports from the recorded data and extract features directly from the signals without having to do any coding. *biosignalsplux* Research and Professional lab kits already include some or all of the add-ons upon purchase, although add-ons can also be purchased individually in our web store.

You can download the newest version of OpenSignals (r)evolution here:

<http://biosignalsplux.com/index.php/en/software/opensignals>

### 9.2 OpenSignals Mobile

*OpenSignals Mobile* is a slimmed down version of *OpenSignals (r)evolution* specifically designed to run on Android® mobile phones or tablets (iOS coming soon), while preserving the ease-of-use and performance for real-time sensor data visualization and recording.

*OpenSignals Mobile* is currently in development. However, if you are interested in being one of the first few users to get your hands on a beta version of this app, visit our *OpenSignals* website and fill in the form to subscribe for the early access beta version.

<http://biosignalsplux.com/index.php/en/software/opensignals>

### 9.3 APIs

It is possible to connect the devices to third party applications including your own custom software. The needed toolkits to start your own biosignal software are delivered by PLUX for free. All the functionalities and features of our high-end research devices can be accessed by developers to integrate PLUX systems in custom and third-party applications.

Visit the official *biosignalsplux* API website to check the list of the available APIs:

<http://biosignalsplux.com/index.php/en/development/apis>



## 10 Troubleshooting

### 10.1 Bluetooth

Most internal Bluetooth adapters are compatible with PLUX devices. However, if you're experiencing a great number of connection loss events, reconnection problems, missing samples or similar problems, your internal Bluetooth module might not have enough performance to deal with the data throughput of the device you are using. In this case, reducing the sampling frequency or the sample resolution might solve this issue, if a change of these parameters is possible.

For this reason, PLUX has identified Bluetooth dongles that have been tested and are known to work with our devices. We recommend that you use one of these PLUX-tested Bluetooth dongles, which are either already shipped with your device (e.g. in the case of *biosignalsplux* kits) or can be purchased separately from our store. These dongles are compatible to work with data rates up to 24 Mbps.

The solution is to exchange the internal Bluetooth Adapter for an **external Bluetooth USB dongle that uses the Windows native Bluetooth stack**. For this, you'll need to install the Bluetooth dongle properly, as described in the following steps, which are explained in more detail throughout the next pages for the supported operating systems:

- Step 1: Removing already paired devices from your operating system
- Step 2: Installing PLUX-proven Bluetooth dongle
- Step 3: Changing Bluetooth Stack to Microsoft's native Bluetooth stack

#### NOTE

If you're already using PLUX devices with the old Bluetooth stack, please remove your device(s) from your computer **before** changing the Bluetooth drivers/changing to Microsoft Bluetooth Stack.

#### NOTE

We recommend going through all the following steps to set up your Bluetooth dongle correctly, even if Windows may automatically install and set up your dongle.

#### NOTE

Installing the Bluetooth dongle and changing the Bluetooth stack is only required for Windows computers only. Computers with a Mac OS X operating system do not need to go through these steps and use the internal Bluetooth adapter instead.

### 10.1.1 Windows 7 & Windows 8

#### Step 1: Removing already paired devices from your operating system

To remove Bluetooth devices, it is needed to access the *Device Manager* on your computer and view the list of connected devices. The device list can be found following these steps:

Start Button > Control Panel > Hardware and Sound > View devices and printers

In the *Device and Printers* window, PLUX devices can be found in the *Unspecified* section. Right-click on the device you want to remove and select *Remove device* (see Figure 121)

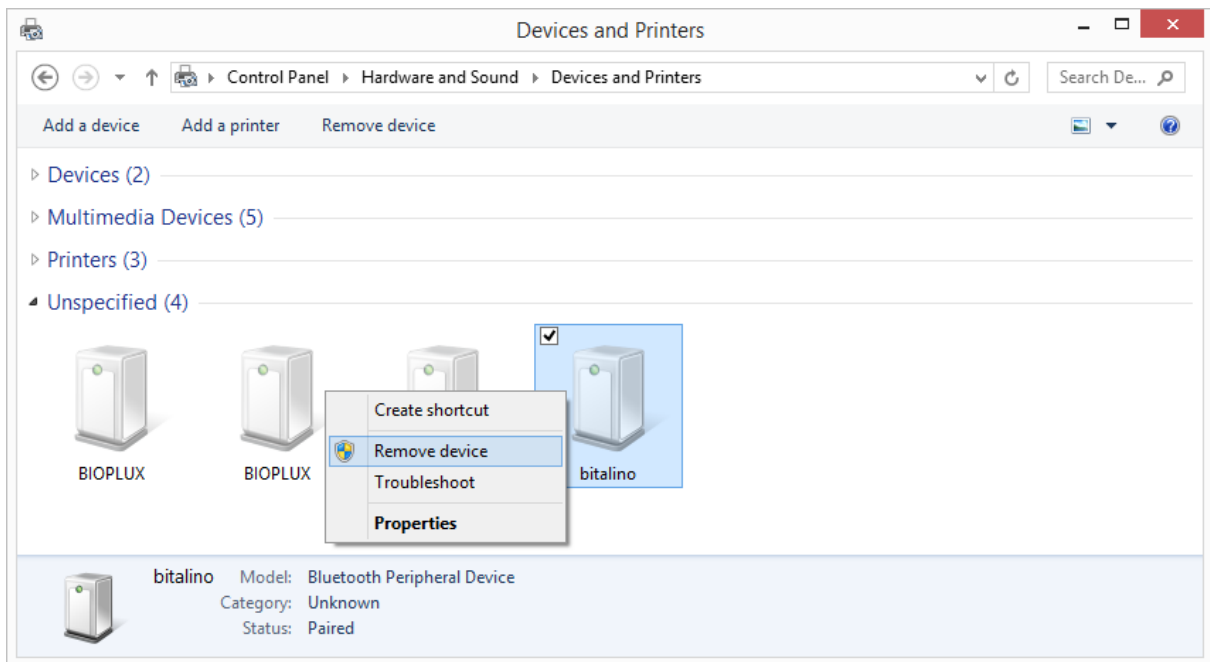


Figure 121: Windows 7 "Devices and Printers" window.

If the device is not listed under *Unspecified* anymore, it has been successfully removed from your system.

#### Step 2: Installing PLUX-proven Bluetooth dongle

To install the PLUX-proven Bluetooth dongle, plug it in and install all the necessary drivers for the Bluetooth dongle to work (an Internet connection is advisable). Windows should display the window below.

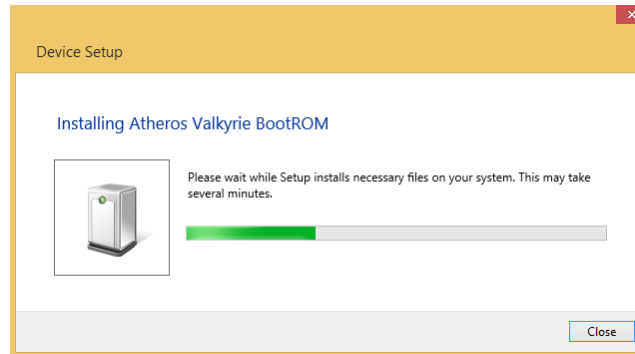


Figure 122: Wait for Windows to install your Bluetooth dongle.

Make sure you wait until your Bluetooth Dongle is installed. Windows will issue a notification and you'll be ready to configure the correct Bluetooth stack following the next step.

### Step 3: Changing Bluetooth Stack to Microsoft's native Bluetooth stack

To configure the Bluetooth stack of the Bluetooth dongle, you have to connect your Bluetooth dongle to your computer and access the *Device Manager* on your computer. The device manager can be found following these steps:

Start Button > Control Panel > System and Maintenance > Device Manager

In the device manager, the Bluetooth dongle should be listed as *Generic Bluetooth Adapter* (see Figure 123). If your machine already has an internal Bluetooth Adapter and you have just plugged in the PLUX-proven Bluetooth Dongle, keep in mind that the last one will be automatically disabled by Windows. This is why one of your Bluetooth adapters under Bluetooth in the device manager shows a yellow warning icon ( ⚠ ) stating: *Code 10 - This device cannot start.*

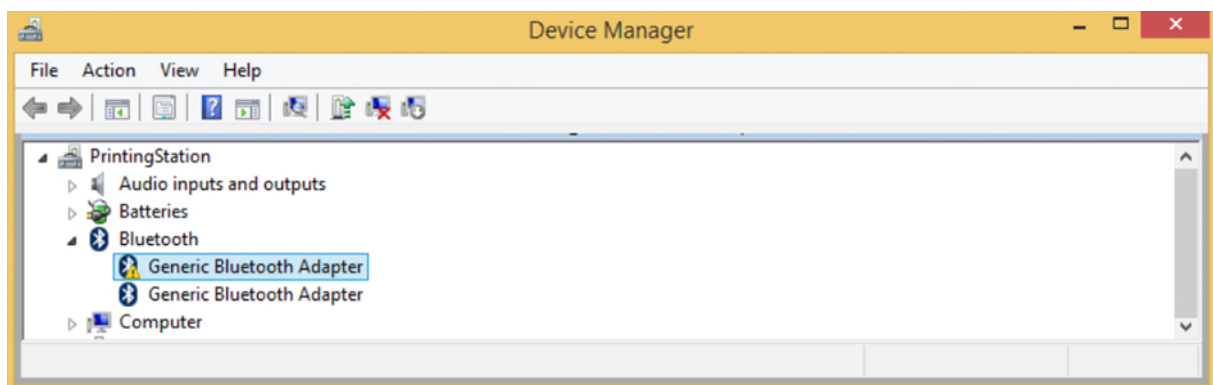



Figure 123: Bluetooth dongle listed in the device manager.

If your Bluetooth dongle is the one disabled, you can manually disable your internal Bluetooth adapter by right-clicking on it in the device manager and selecting *Disable*. This action will enable your Bluetooth dongle by default.

If, after this action, your Bluetooth Dongle continues to display a yellow warning icon

(  ), it means that it is not installed correctly and you should try to update the drivers by right-clicking on it and selecting *Update Driver Software...* or fix the problem displayed under *Device Status* in the device properties (right-click the Bluetooth device and select Properties; see screenshot below).

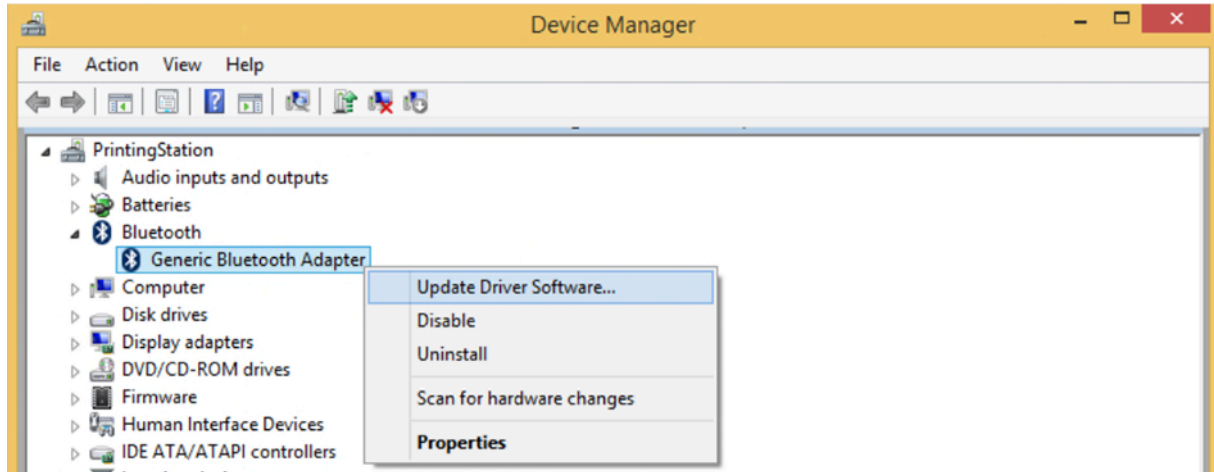


Figure 124: First step to update the driver of the Bluetooth dongle.

Select *Browse my computer for driver software* from the new window.

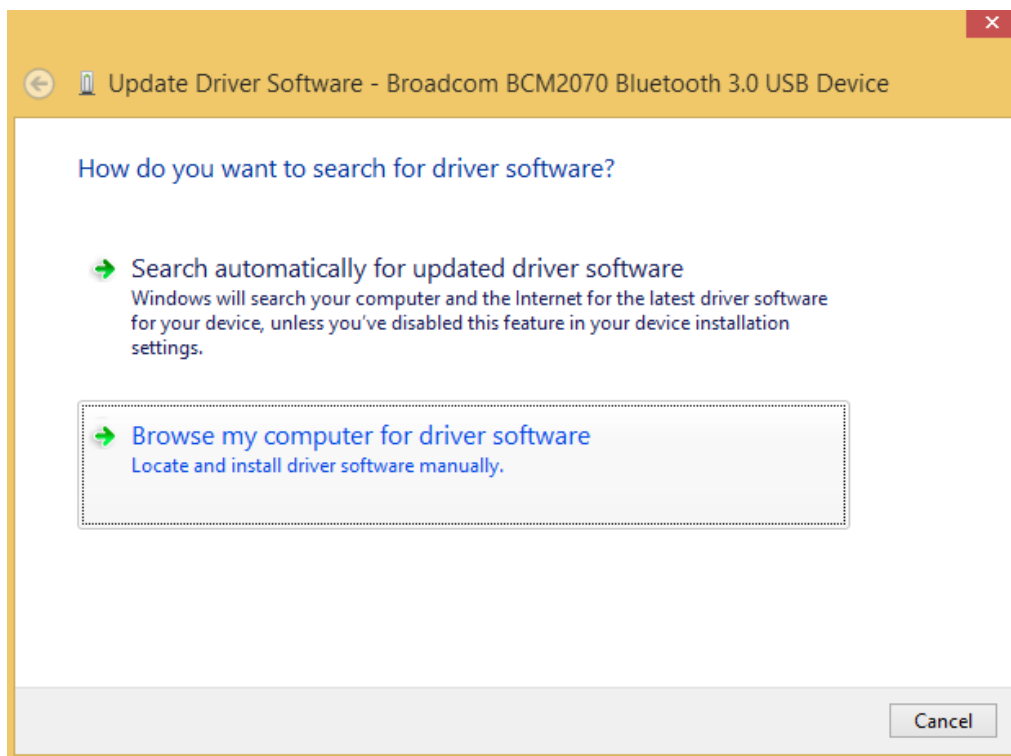


Figure 125: Browse for driver software.

Select *Let me pick from a list of device drivers on my computer.*

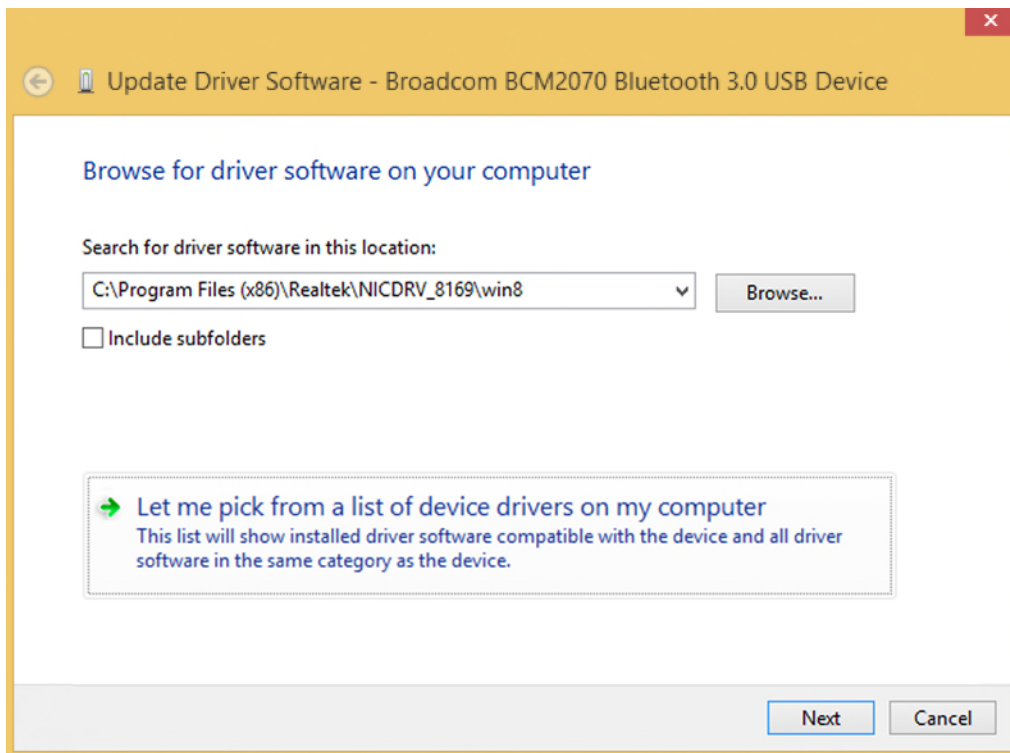


Figure 126: Pick driver from list of device drivers on the computer.

Select *Generic Bluetooth Adapter* and click on *Next* to install the Microsoft Bluetooth Stack. Of several models of *Generic Bluetooth Adapter* are available you can select any of them. It will not make any difference.

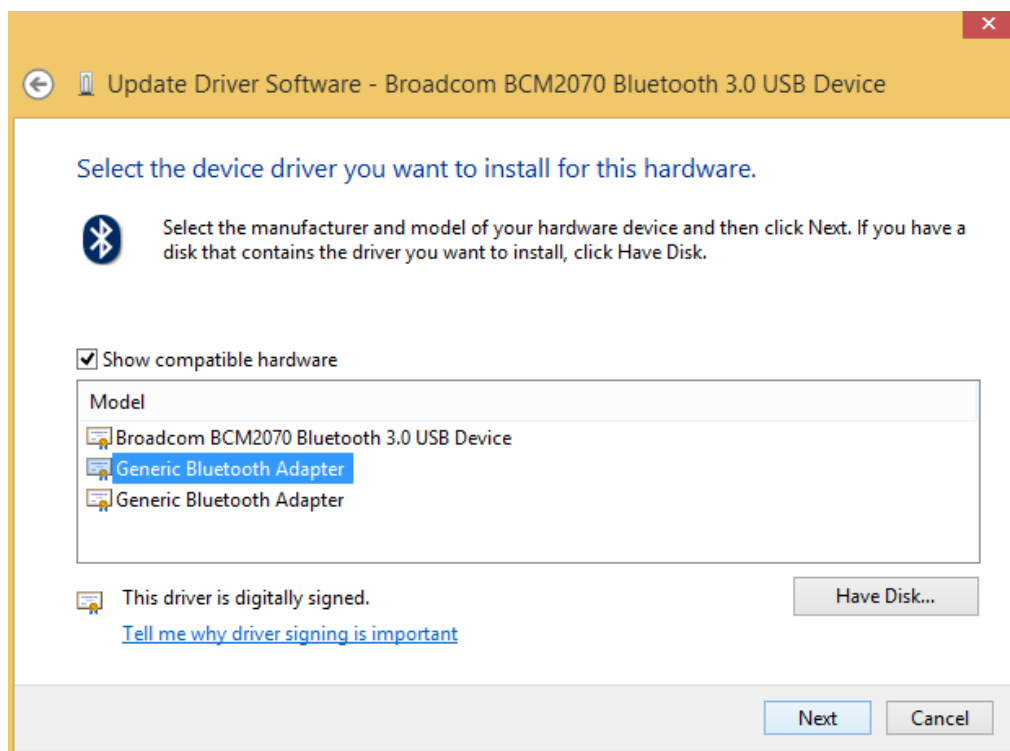


Figure 127: Select Generic Bluetooth Adapter

Your device should now be configured properly and have no warning sign or error message in the device manager. Rebuild the connection with your *biosignalsplux* device (see *Bluetooth Setup Windows 7*) and test your device by recording signals with the *OpenSignals (r)evolution* software. If, after all these steps, you keep experiencing the same issues, contact our support

### 10.1.2 Windows 10

#### Step 1: Removing already paired devices from your operating system

To remove Bluetooth devices, it is needed to access the Bluetooth configuration of your operating system. Click on the start button at the left lower corner in of your desktop to open the start menu. Click on the gear symbol to open the settings panel of your operating system as can be seen below.

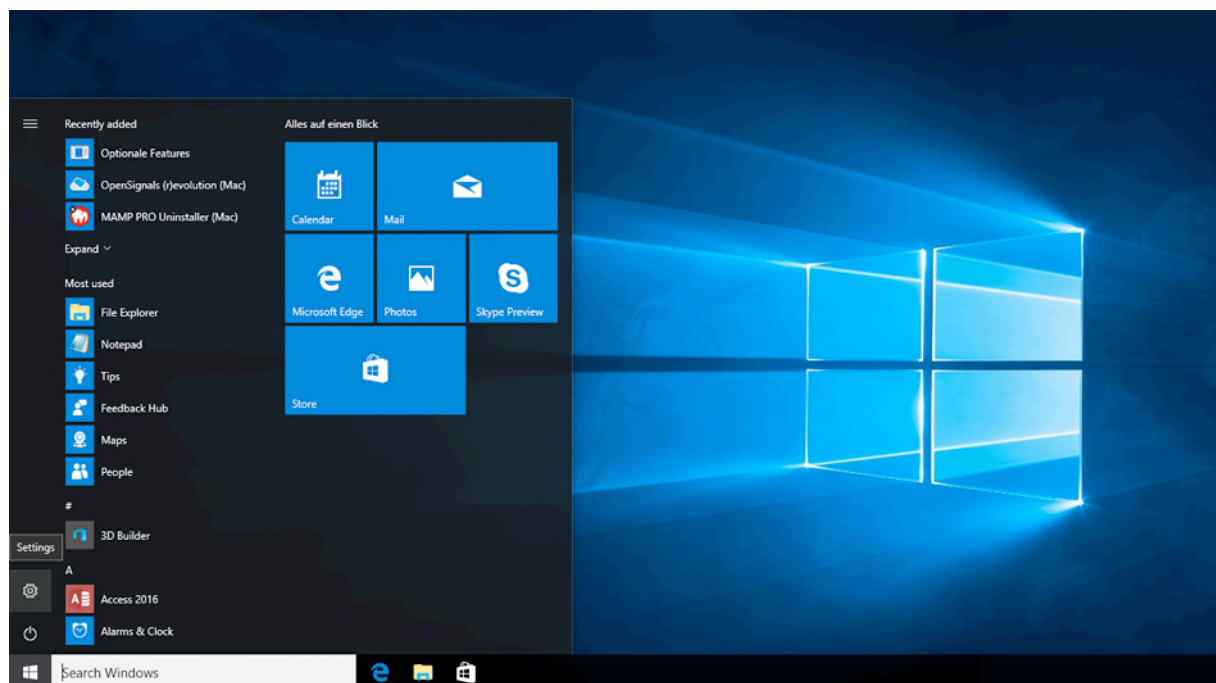


Figure 128: Access to the settings panel in Windows 10.

In the settings panel, click on the *Devices Bluetooth, printers, mouse* field to open the device configurations of your system.

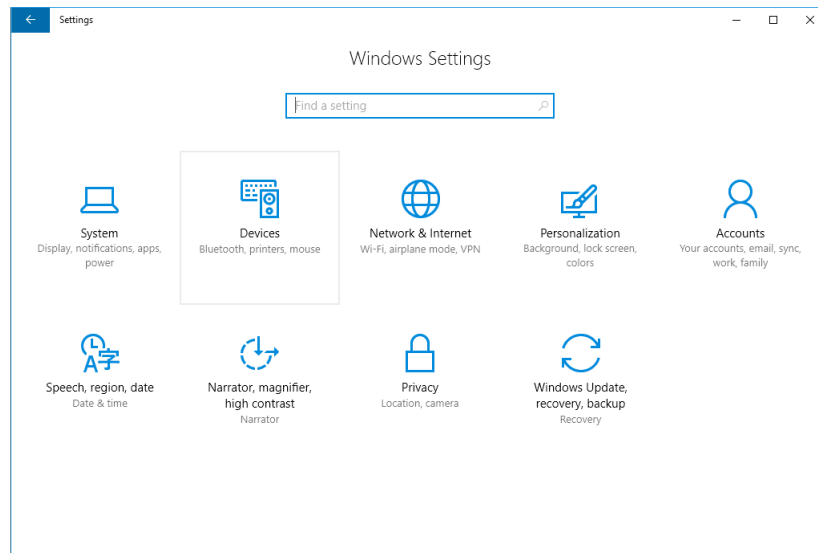


Figure 129: Windows 10 settings panel.

Select *Bluetooth* from the list which is displayed on the left side of your settings window. Note, that in some versions the Bluetooth option might not be available and that Bluetooth devices might be listed under *Other devices*.

Click on your *biosignalsplux* and click on *Remove device* to remove this Bluetooth connection from your computer and confirm the *Are you sure you want to remove this device?* message that will be shown on your screen. Repeat this step with every *biosignalsplux* if you're using several devices.

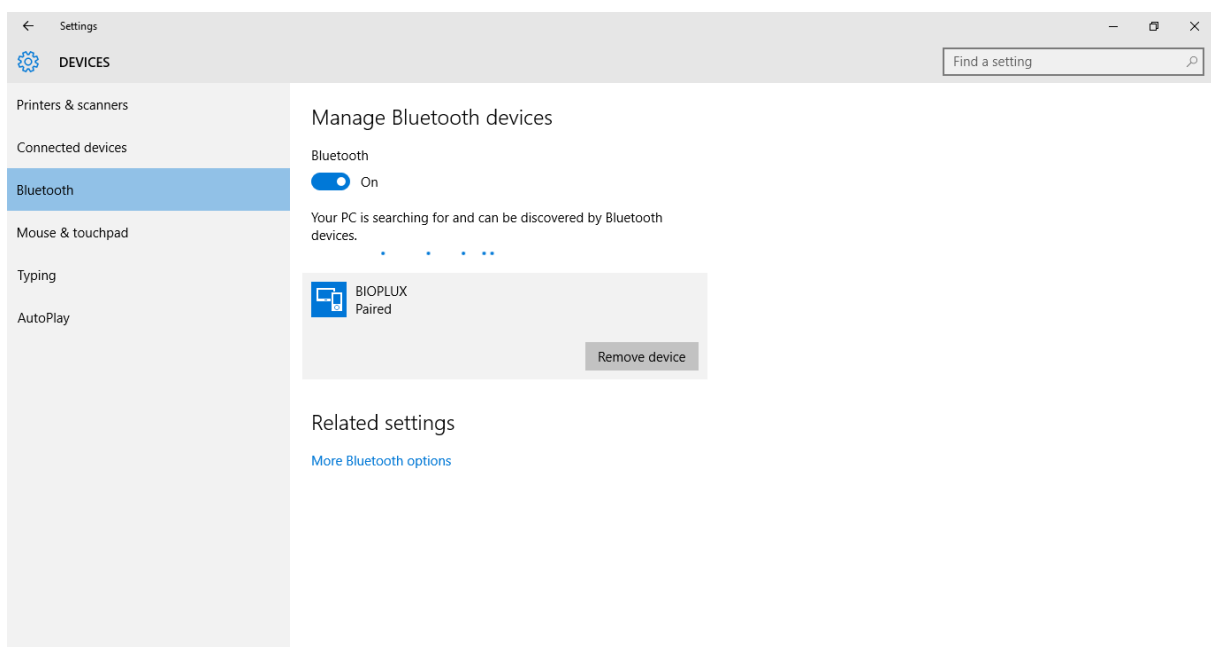


Figure 130: Windows 10 Bluetooth devices

If, after this step, your device is not listed in the list of Bluetooth devices anymore, the device has been successfully removed.

## Step 2: Installing PLUX-proven Bluetooth dongle

To install the PLUX-proven Bluetooth dongle, plug it into your computer. Windows will install the Bluetooth dongle and display the window below.

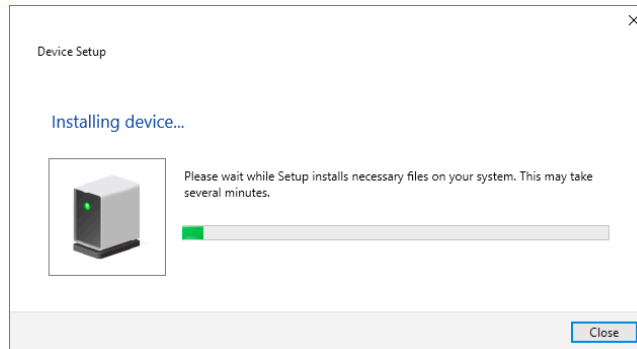


Figure 131: Wait for Windows to install your Bluetooth dongle.

Make sure you wait until your Bluetooth Dongle is installed. Windows will issue a notification and you'll be ready to configure the correct Bluetooth stack following the next step. Note, that this step might require a restart of your system. Make sure to close all your open work and programs properly before restarting the system to prevent data losses or other issues.

## Step 3: Changing Bluetooth Stack to Microsoft's native Bluetooth stack

To configure the Bluetooth stack of the Bluetooth dongle, you have to connect your Bluetooth dongle to your computer and access the *Device Manager* on your computer. Enter *Device Manager* into the search field of your taskbar and click on the listed device manager.

In the device manager, the Bluetooth dongle should be listed as *Generic Bluetooth Adapter* (see ). If your machine already has an internal Bluetooth Adapter and you have just plugged in the PLUX-proven Bluetooth Dongle, keep in mind that the last one will be automatically disabled by Windows. This is why one of your Bluetooth adapters under Bluetooth in the device manager shows a yellow warning icon ( ⚠ ) stating: *Code 10 - This device cannot start*.

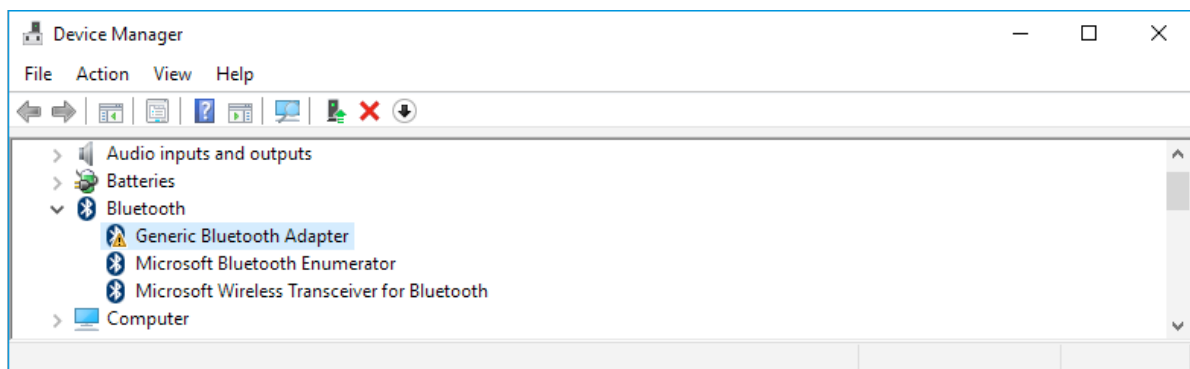


Figure 132: Bluetooth dongle listed in the device manager.



If, after this action, your Bluetooth Dongle continues to display a yellow warning icon (⚠), it means that it is not installed correctly and you should try to update the drivers by right-clicking on it and selecting *Update Driver Software...* or fix the problem displayed under *Device Status* in the device properties (right-click the Bluetooth device and select Properties; see screenshot below).

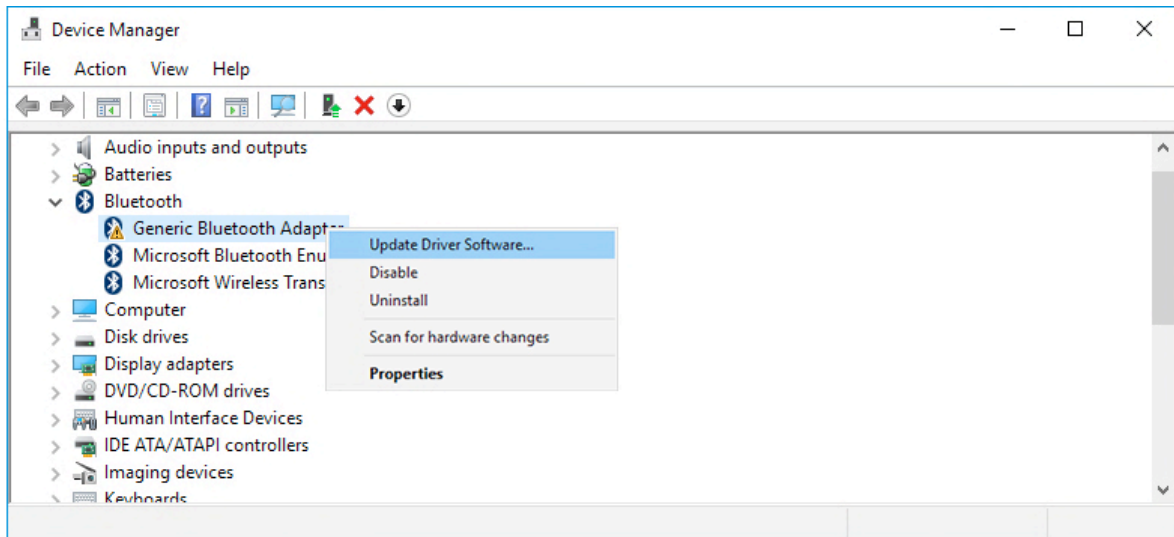


Figure 133: First step to update the driver of the Bluetooth dongle.

Select *Browse my computer for driver software* from the new window.

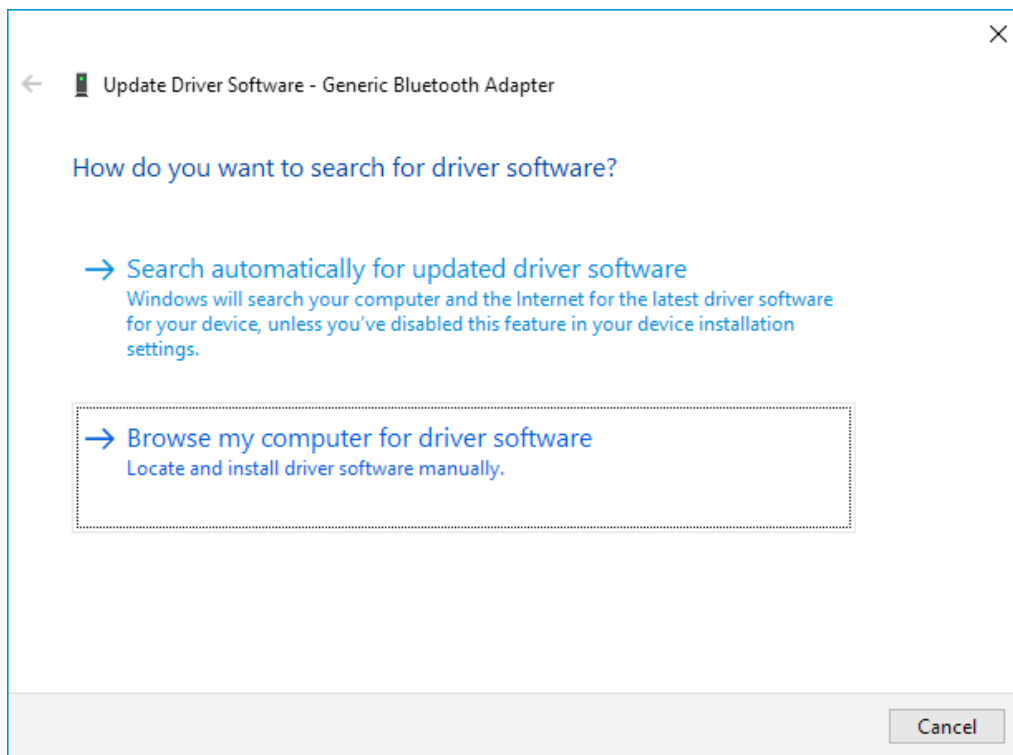


Figure 134: Browse for driver software.

Select *Let me pick from a list of device drivers on my computer.*

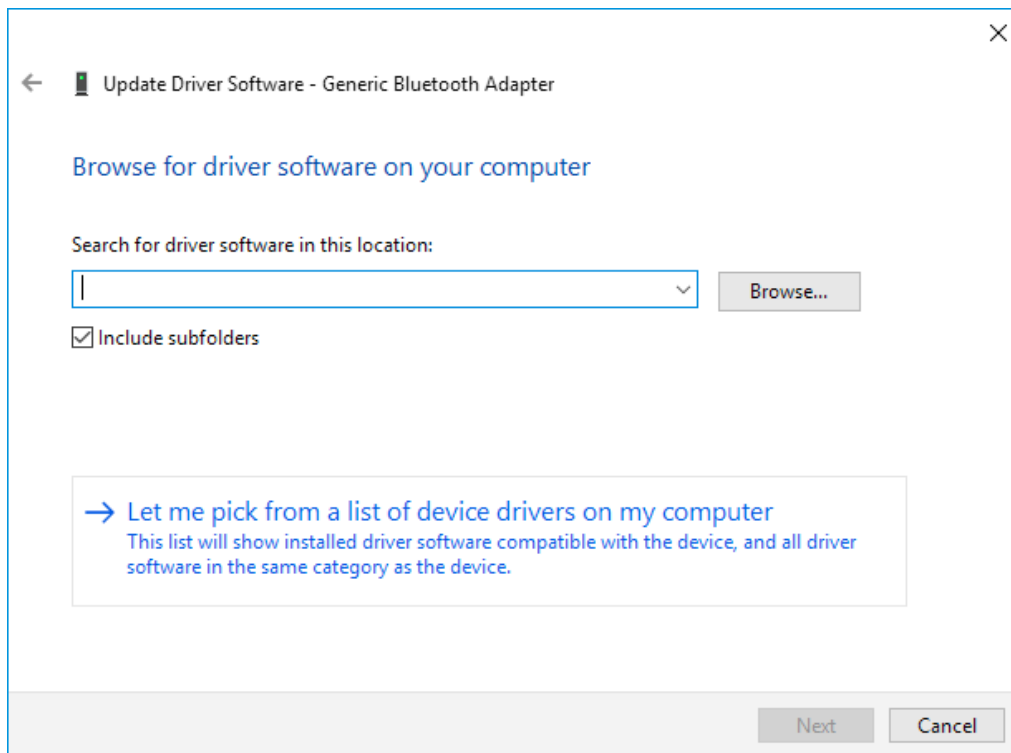


Figure 135: Pick driver from list of device drivers on the computer.

Select *Generic Bluetooth Adapter* and click on *Next* to install the Microsoft Bluetooth Stack. Of several models of *Generic Bluetooth Adapter* are available you can select any of them. It will not make any difference.

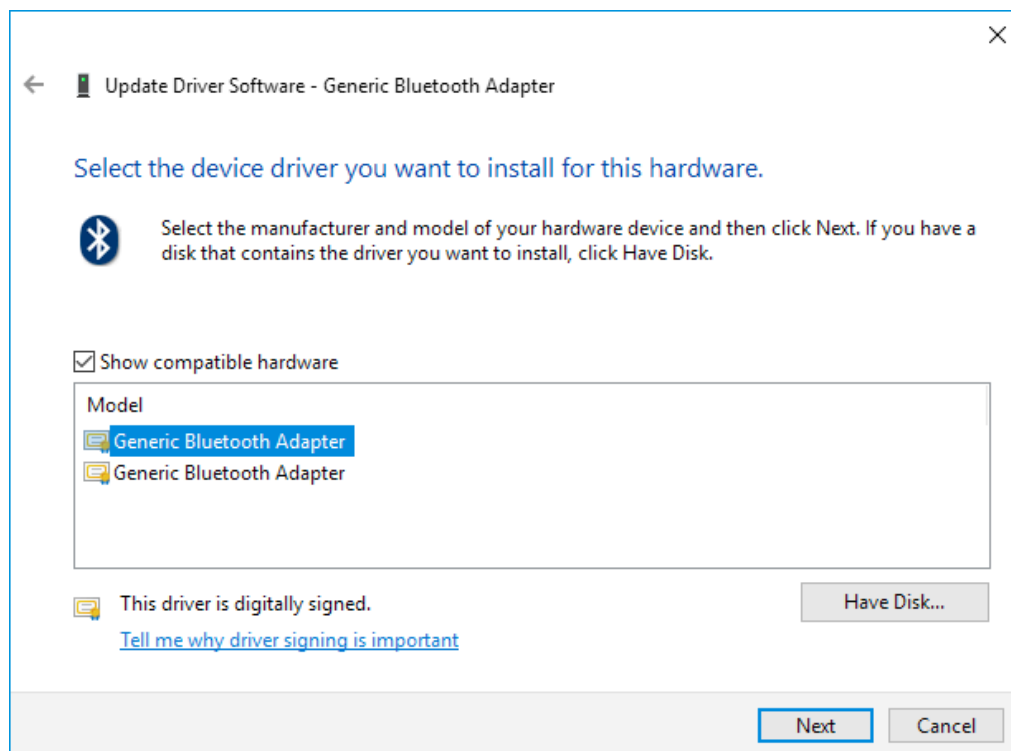


Figure 136: Select Generic Bluetooth Adapter

Your device should now be configured properly and have no warning sign or error message in the device manager. Rebuild the connection with your *biosignalsplux* device (see *Bluetooth Setup Windows 10*) and test your device by recording signals with the *OpenSignals (r)evolution* software. If, after all these steps, you keep experiencing the same issues, contact our support

## 11 Safety & Maintenance

Please read the following safety instructions **before** using your *biosignalsplux* system 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.
- ! The user should not use the *biosignalsplux* device continuously for periods of time above 60 minutes. 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.

## 11.1 Maintenance Recommendations

### 11.1.1 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 bac and avoid dropping it, since the device is not shock-proof and should not be placed under stress or sudden acceleration.

### 11.1.2 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 or 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.

## 12 Regulatory & Legal Information

### 12.1 Disclaimer

***biosignalsplux* products are intended for use in life science education and research applications only; *biosignalsplux* products are not medical devices**, nor medical software solutions, nor are they intended for medical diagnosis, cure, mitigation, treatment or prevention of disease and is provided to you “as is”.

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.

### 12.2 Guarantee of Quality & Warranty

The *biosignalsplux* acquisition system has a two years quality guarantee from the date of purchase. *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.

#### 12.2.1 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 3<sup>rd</sup> 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 3<sup>rd</sup> 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.



### 12.3 Contact & Support

Contact us if you're experiencing any problems that cannot be solved with the information given in the *biosignalsplux* or OpenSignals (r)evolution manual. We'll get back to you as soon as possible to find the best solution for your problem.

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](mailto:support@plux.info).

## 13 Datasheets

The information displayed in this manual is taken from the official *biosignalsplux* datasheets. Please read the datasheets of your hub, sensors, and/or accessories before using them. The datasheets can be accessed via the links below.

biosignalsplux Hub

[http://biosignalsplux.com/datasheets/biosignalsplux\\_hub\\_Spec\\_Sheet.pdf](http://biosignalsplux.com/datasheets/biosignalsplux_hub_Spec_Sheet.pdf)

Accelerometer (ACC)

[http://biosignalsplux.com/datasheets/ACC\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/ACC_Sensor_Datasheet.pdf)

Blood Volume Pulse (BVP)

[http://biosignalsplux.com/datasheets/BVP\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/BVP_Sensor_Datasheet.pdf)

Breakout Cable

[http://biosignalsplux.com/datasheets/IO\\_Breakout\\_Cable.pdf](http://biosignalsplux.com/datasheets/IO_Breakout_Cable.pdf)

Electrocardiography (ECG)

[http://biosignalsplux.com/datasheets/ECG\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/ECG_Sensor_Datasheet.pdf)

Electrodermal Activity (EDA)

[http://biosignalsplux.com/datasheets/EDA\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/EDA_Sensor_Datasheet.pdf)

Electroencephalography (EEG)

[http://biosignalsplux.com/datasheets/EEG\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/EEG_Sensor_Datasheet.pdf)

Electromyography (EMG)

[http://biosignalsplux.com/datasheets/EMG\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/EMG_Sensor_Datasheet.pdf)

Goniometer (GON)

[http://biosignalsplux.com/datasheets/GON\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/GON_Sensor_Datasheet.pdf)

Handheld Switch

[http://biosignalsplux.com/datasheets/BTN\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/BTN_Sensor_Datasheet.pdf)

LED

[http://biosignalsplux.com/datasheets/LED\\_Actuator\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/LED_Actuator_Datasheet.pdf)

Light (LUX)

[http://biosignalsplux.com/datasheets/LUX\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/LUX_Sensor_Datasheet.pdf)

Load Cell

[http://biosignalsplux.com/datasheets/Load\\_Cell\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/Load_Cell_Datasheet.pdf)

Respiration (RIP)

[http://biosignalsplux.com/datasheets/RIP\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/RIP_Sensor_Datasheet.pdf)

Respiration (PZT)

[http://biosignalsplux.com/datasheets/PZT\\_Sensor\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/PZT_Sensor_Datasheet.pdf)

Synchronization Kit (SYNC) (incl. Digital Synchronization Cable & Multi Sync Splitter)

[http://biosignalsplux.com/datasheets/SYNC\\_Accessory\\_Datasheet.pdf](http://biosignalsplux.com/datasheets/SYNC_Accessory_Datasheet.pdf)