



PLUX
ERGO

user manual



user manual

[version 1.0, 7th December 2011]

ATTENTION: please read this manual before using your bioPLUX clinical product.

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



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user manual

Index

Chapter 1: Your ergoPLUX system.....	5
Contents of the packaging.....	7
Capítulo 2: Hardware.....	8
Getting started with your bioPLUX device.....	8
Know the device.....	8
Switching it on.....	9
Status indicator	10
Symbology.....	12
Connecting the sensors	13
Disconnecting the sensors.....	14
Recharging.....	15
Accessories.....	16
Bluetooth adapter installation.....	16
Set of sensors.....	17
How to use the electromyography sensors (sEMG).....	18
How to use the triaxial accelerometer	20
Chapter 3: Software.....	22
Start menu.....	22
If you are using the software for the first time.....	23
Workers.....	24
Add worker.....	25
Select worker.....	27
Edit worker.....	28
Protocols	29
System messages.....	30
Session.....	31
Muscular Load Protocol.....	32
Exposure to Vibration Protocol.....	35
Reports	38
Muscular Load Report.....	41
Exposure to Vibration Report.....	42
Chapter 4: Information about safety, support and quality.....	43
Classification and identification.....	43
Contraindications.....	43
Warnings.....	44
Electromagnetic emissions.....	47



user manual

Maintenance recommendations.....	48
Cleaning.....	48
Transport and storage.....	48
Technical specifications.....	49
bioPLUX device.....	49
Charger.....	49
Bluetooth adapter.....	50
Technical assistance.....	51
Guarantee of quality.....	52
Appendix.....	53





user manual

Chapter 1: Your ergoPLUX system

The ergoPLUX system makes the acquisition of the signals acquired from the user's body through the sensors and transmits them in real time via Bluetooth to the computer, where they are processed and displayed in real time, during the exercises shown on the computer monitor.

The visual effects that appear animated on the computer screen as a result of processing the signals work as a source of feedback to the user.

At the end of each evaluation session, a report with the results is generated automatically and added to the user profile in the database system.

Work-related musculoskeletal disorders are pathologies acquired cumulatively due to work activities which are frequent and repetitive, or activities with constrained postures and which may comprehend a pace of work that does not allow sufficient recovery between movements.

The purpose of this system is to evaluate the occupational exposure and the risk of musculoskeletal injuries during the work period.

The evaluation of the occupational risk exposure can be done by electromyography (emg) and vibration monitoring (using accelerometers). The emg assess the muscular activity and can be used for a comparative analysis of the work done and the muscular load demanded from it. Vibrating tools can transmit intense vibrations which, depending on type or local of work, can affect the hand-arm system or the whole body.

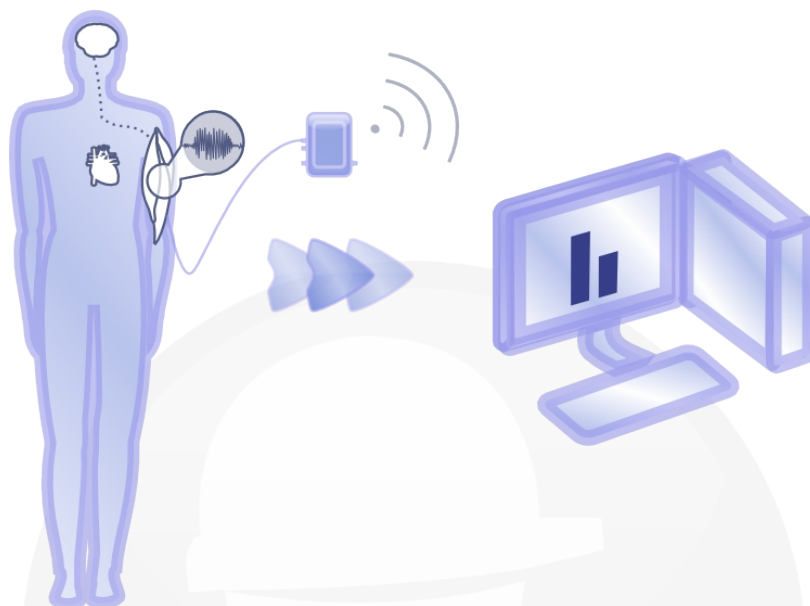
The biosignals resulting from muscle activity and acceleration are translated by the software in graphics and animation appealing to the user, showing his occupational risk exposure and what contributes the most for that risk.

The ergoPLUX has a major philosophy of ease of use, flexibility, reliability and portability.

The operating principle of the ergoPLUX is based on three fundamentals: to connect, acquire and visualize. The objective of this system is to make use of a good security practice at work, facilitating the evaluation of the ergonomist and, through a nice interface, enhance the perception of risks the user is subject during a normal work day.



user manual



The ergoPLUX collects the user's biosignals through the sensors that are placed on his skin, and which are connected to the bioPLUX device. This device acquires the signals and sends them (in real time) via Bluetooth to the computer. These signals are processed and transformed into attractive graphics and animations that are viewed by the user and ergonomist on the computer screen through the ergoPLUX software.

The software offers all the functionality that is intended to be implement by the ergoPLUX product: visualization in real-time of the running protocol session, visualization of reports from previous sessions, printing of reports and checking of historical charts of sessions.



user manual

Contents of the packaging



The package contains:

- 1 bioPLUX wireless system for biosignals acquisition
- 1 CD with setup for installation of the ergoPLUX software and user manual
- 5 sensors for surface electromyography
- 1 ground electrode
- 1 accelerometer for vibrations measurement
- 25 reusable detection surfaces
- 1 charger for the bioPLUX device
- 1 Bluetooth pen adapter

NOTE: Extra sensors can be purchased from PLUX. Check the list of accessories on page 17 to know the PLUX sensors available.



user manual

Capítulo 2: *Hardware*

Getting started with your bioPLUX device

Know the device

The bioPLUX is the device that collects and digitizes the signals from the sensors and transmits via Bluetooth to the computer, where they are visualized in real time.

The channels of bioPLUX have 12 bits of resolution, and its sampling frequency is 1000Hz.

The bioPLUX also has a digital port, a terminal for connecting the AC adapter and charge the internal battery (which allows an autonomy of 12 hours), and a channel to connect the reference electrode (ground cable), which is essential for the proper monitoring of electromyography signal.

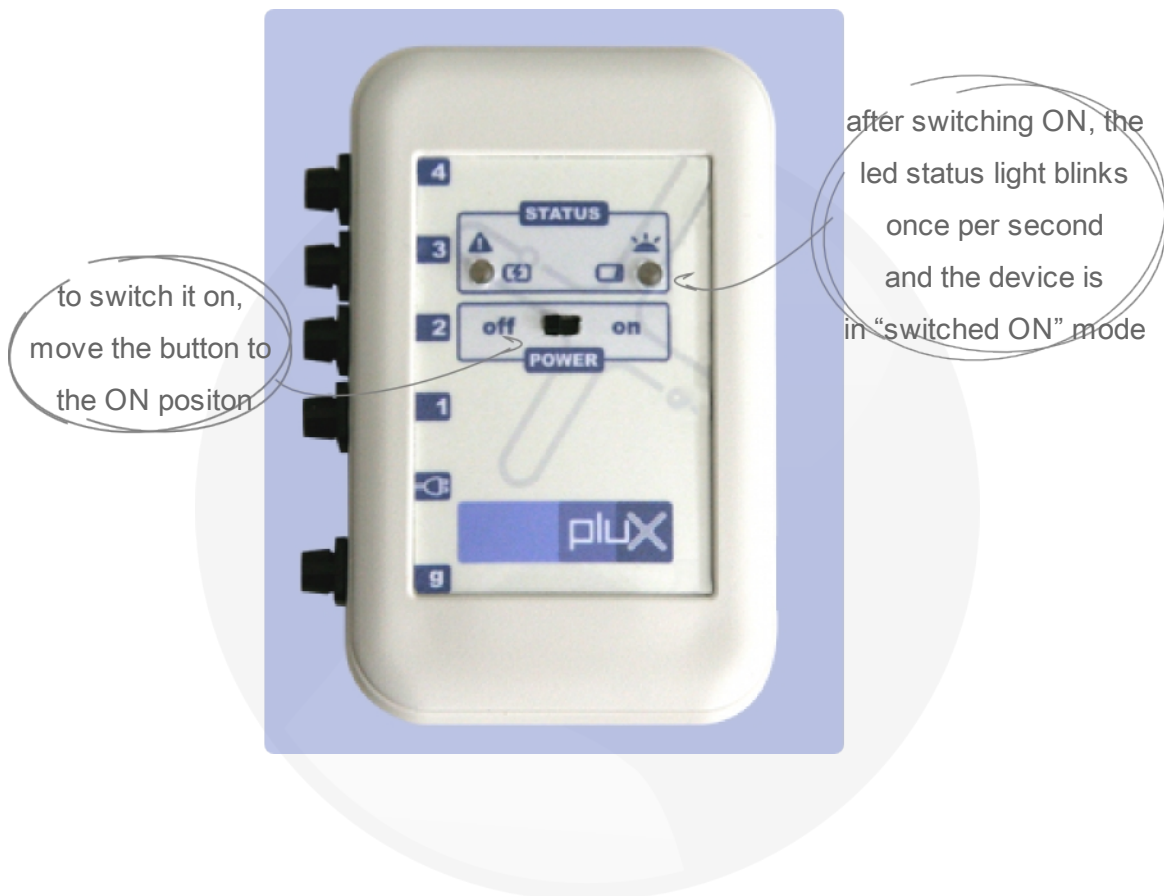




user manual

Switching it on

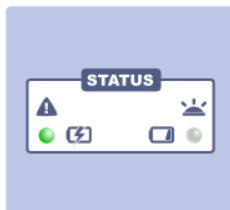
In order for the device to work, it must be switched on:



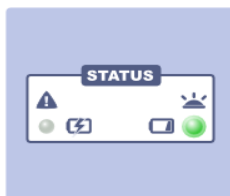


user manual

Status indicator



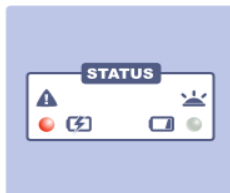
Status: Charging (solid green light)
bioPLUX is switched off and recharging



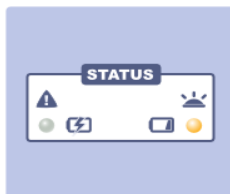
Status: Standby (blinking green light once per second)
bioPLUX is on and on standby



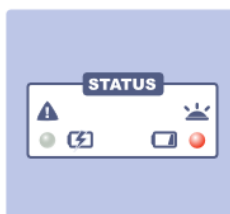
Status: Synchronized (green led blinks twice per second.)
bioPLUX is sending data to the computer



Status: Recharging alert (solid red led)
Alert that in the last usage, the device was fully discharged.
Reconnect the charger.



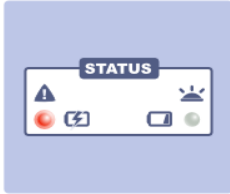
Status – Low Battery while Synchronized (orange led blinking)
Battery is low. Recharge the device.



Status – Low Battery (solid red led)
Battery is low. Recharge the device.



user manual



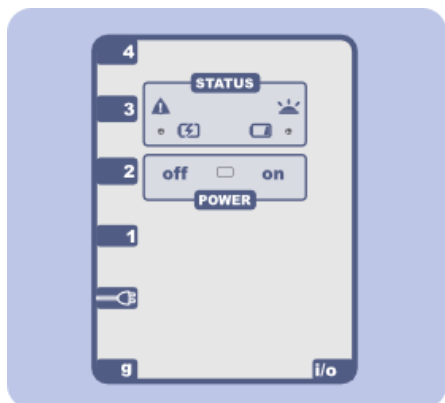
Status: Error (blinking red led)
Overheating or transformer has wrong current





user manual

Symbology



Indicator leds of bioPLUX status



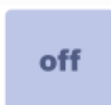
On\off switch



In this position, equipment is on.



Digital input\output terminal



In this position, equipment is off.



Status indicator
(see page 10)



Channel to connect reference electrode



Low battery indicator
(see page)



Transformer connector to recharge
bioPLUX equipment



Error\warning indicator
(see page)



Low battery\recharging indicator
(see page)

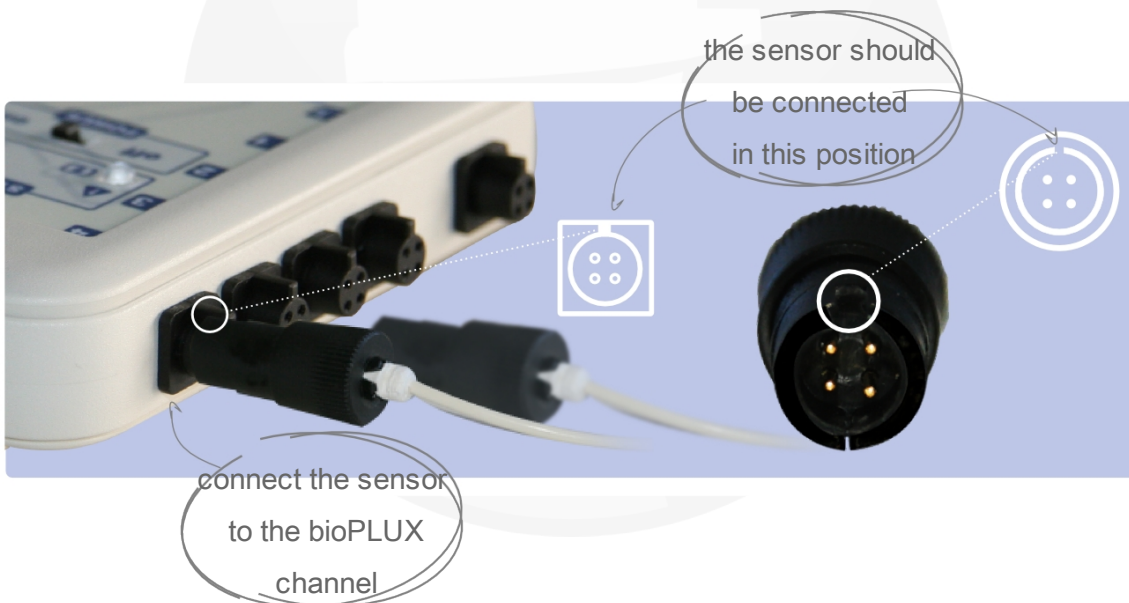


user manual

Connecting the sensors

The sensors should be connected to channels one through 8 as shown in the figure below. The reference electrode should be connected to the respective channel (g). Take care not to connect the sensors to the digital input/output channel (see identification of channels on page 8).

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





user manual

Disconnecting the sensors

To avoid damaging the bioPLUX device or the sensors, they should be disconnected in line with the recommendations shown below:





user manual

Recharging



The bioPLUX has an autonomy of approximately 12 hours in continuous usage. When the battery starts to run down, the respective led light gives a warning (see page 16) until the device stops working. At this point you need to recharge the battery.

To charge the battery of your bioPLUX device all you have to do is plug the charger to a wall outlet and to the charging terminal on your bioPLUX device

For the safety of the user being monitored, the bioPLUX device **automatically switches off when in charging mode (state: charging)**

Important: when charging the bioPLUX you must remove all sensors connected to the user!

The bioPLUX battery will take approximately two and a half hours to fully charge. When this process is finished and the battery is fully charged the led charge warning light switches off.

If an error occurs during charging, a red led warning light comes on (see page 10). In this case, you must unplug the charger from the wall outlet and plug it again to complete the charging process correctly.

The room temperature when charging the battery must be between 10°C and 35°C.

If the battery overheats (reaching 60°C), unplug the charger immediately and contact PLUX Technical Assistance.

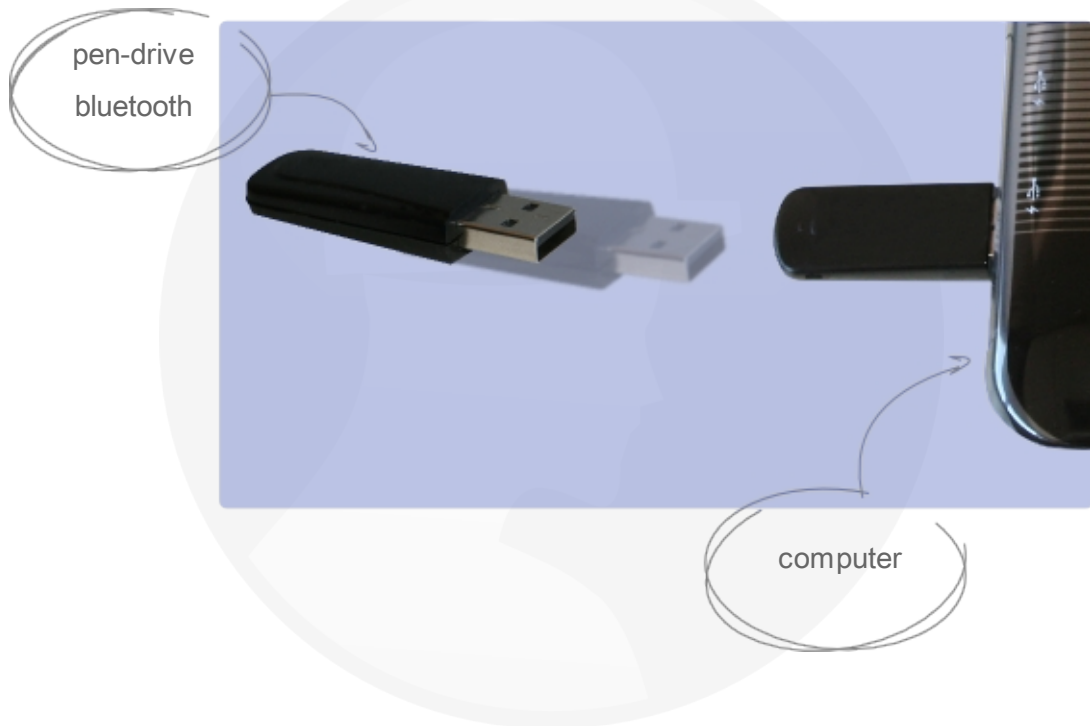


user manual

Accessories

Bluetooth adapter installation

The Bluetooth adapter should be connected to the computer through a USB port.





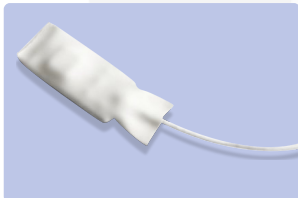
user manual

Set of sensors



emgPLUX surface electromyography sensor

Our miniaturized **sEMG active sensors** have low noise characteristics that allows them to be used in the most adverse condition of EMG acquisition. The amplification and signal conditioning elements placed near the acquisition area maximizes the sensors performance and final signal quality. Some of the applications of this sensor include fatigue evaluation, muscle contraction monitoring and muscular activation instants analysis.



xyzPLUX accelerometer sensor

Our triaxial accelerometer is robust, stable, accurate, with a dynamic range of $\pm 3g$ and due to it's small size, it's integration is very easy. It has been developed for applications where cinematic and motion measurements are required. This sensor can measure accelerations relative to free fall and the model available is capable of detecting magnitude and direction of this same acceleration, as a vector quantity. This resulting vector can then be used to sense position, vibration, shock, fall, etc.



user manual

How to use the electromyography sensors (sEMG)

The emgPLUX sensors are designed to capture electromyography (sEMG) signals from the skin surface. After the correct placement of the sensor on the muscle that you want to monitor, the signals are captured and transmitted by the bioPLUX device to the computer, where the software process them and translate them into graphics and animations that are displayed, in real time on-screen.

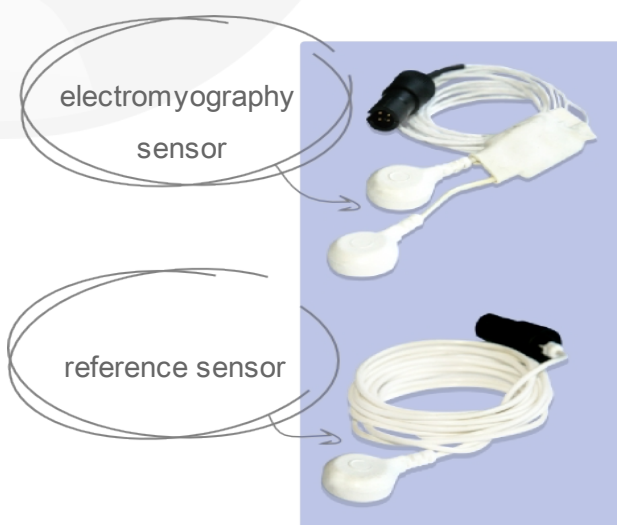
The electromyography sensors provided are bipolar and with variable distance between electrodes, allowing users to apply them in the most convenient muscles for the collection of signals. It is advised that the application of electrodes on the skin should be with a distance of 2 cm between them, with a parallel orientation to the muscle fibers.

For the monitoring of the muscle activity it is necessary to use at all times, a reference electrode with the emgPLUX sensor. This electrode collects the basic electrical signal always present at skin surface and that is not a result of muscle activity (noise). This signal is the reference to measure the signal and the electromyography sensor must be placed on a location with reduced muscle activity. Thus, the electromyography signal captured and processed represents only the signal generated by the activity of the muscle where the bipolar sensor was placed.

The electromyography sensor consists of two electrodes and a connector for the bioPLUX.

The connector can be used on channels 1 to 8, according to the procedure described in page 13.

The procedure to disconnect the sensor is described in page 14.

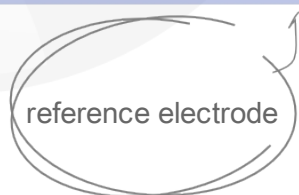




user manual

For proper monitoring of electromyography signal, it is recommended the following:

1. The skin where the sensors are placed (including the reference) must be prepared by removing the existing hair on the surface;
2. Clean the skin with alcohol and let it evaporate before placing the electrodes;
3. Place a detection surface on each electrode;
4. For a good contact of the the electrodes with the skin, you should press firmly the center and the edges of the detection surfaces;
5. The reference electrode should be placed in a place on the body with low electrical activity, like for ex. on the elbow or ankle;
6. Wait about 30 seconds;
7. Connect the sensors to the electromyography acquisition system bioPLUX, to the desired channels (Channel 1 to Channel 4);
8. Connect the reference electrode to the appropriate channel in bioPLUX (channel G);
9. Test, using the software, if the signals recorded by the electromyography sensors are received.



It is advisable to use the disposable and single-user detection surfaces of the type Ag / AgCl.

Important: The pads must not be applied to broken skin or on the nipples, bony protrusions, cuts, lesions or scars. Their use must be personal and should be discarded after use.



user manual

How to use the triaxial accelerometer

The xyzPLUX triaxial accelerometer is designed to measure acceleration from the three axes. This sensor has a high level of sensibility and therefore, for the purpose of measure vibrations, it is advised to use it fixed in a way to minimize the undesirable artifact movements of the sensor.

We provide a band strap with the ergoPLUX system to fix the accelerometer and measure the vibrations in a known location.

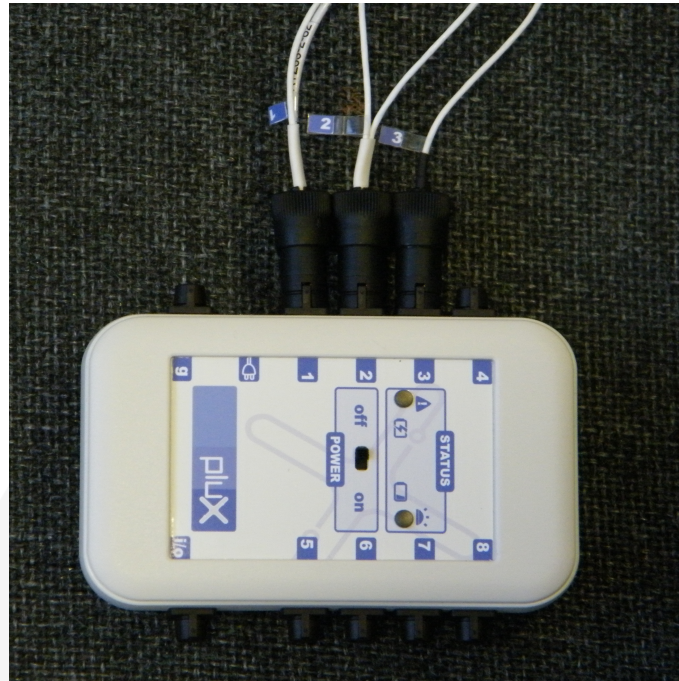
To measure vibrations in the hand-arm system, the accelerometer should be on the hand, in contact with the vibrating tool. To measure vibrations that affect the whole body and when the person is working in a standing position, the band strap should be attached to the shoe (**do not step the device**), and when working in a sitting position the band strap should be positioned in the chair with the worker sitted above it.



Each axis of the accelerometer should be connected to the correct channel of the bioPLUX system. To assist with that, each accelerometer axis has the channel printed in the thread.



user manual



Important: The band strap can be washed but the sensor has to be removed from the small bag first as it cannot be in contact with liquids or detergents.



user manual

Chapter 3: Software

Start menu

The initial menu is shown when the software starts and contains two options:

- workers
access to the users' database (choose protocols, edit user profile and view reports)
- settings
configuration of the mac address





user manual

If you are using the software for the first time

The first time you use the ergoPLUX software, please go to “settings” and check if you have a unique identification code (MAC address) for the bioPLUX system that you are about to use and confirm that this is the same as the one on the MAC address card provided with the system. If not, please contact our support services.

CHANNELS		CALIBRATION	
		MAX.	MIN.
1	X	932	624
2	Y	920	612
3	Z	966	632

MAC ADDRESS
00:07:80:4B:3F:5A

PLUX

device | about ergoPLUX

mac address | 00:00:00:00:00:00|



user manual

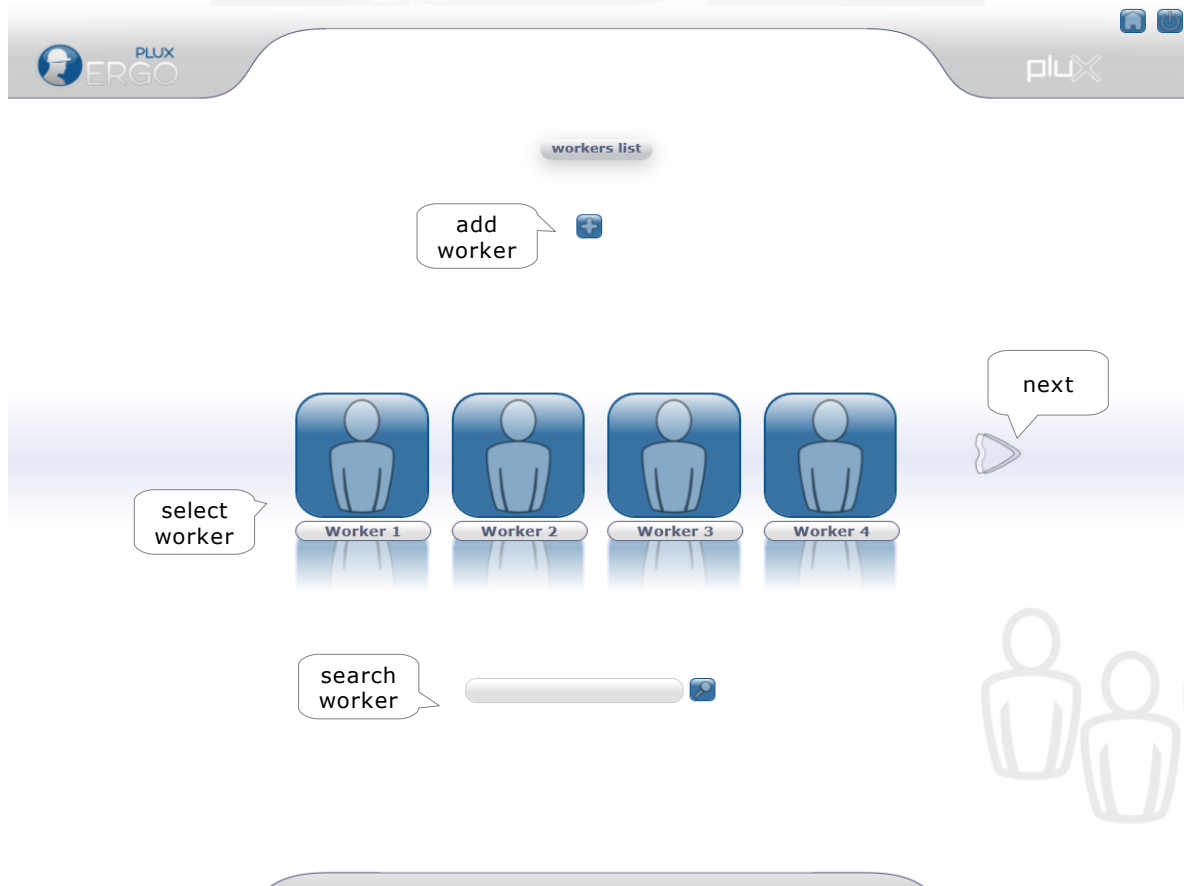
Workers



The "workers" option in the main menu allows to:

- make the management of the users in the database;
- conduct specialized evaluation sessions for each user;
- see the progression of users over time;
- view and print reports of the training sessions.

In this page a list of the current workers is displayed and it is possible to add a new worker or search for a specific worker in the list.





user manual

Add worker

By clicking the "add" button, a form appears to be completed with information about the worker.

The screenshot shows the 'add worker' form in the plux application. The form is divided into two tabs: 'worker info' and 'antropometric measurements'. The 'worker info' tab is active and contains the following fields:

- ID:
- name:
- surname:
- birthdate:
- sex: male female
- start in the company:
- previous work positions:

The 'antropometric measurements' tab is inactive. The 'add worker' section contains the following fields:

- observations:
- work positions:
- name:
- date of start:
- date of end:
- remarks:

Callouts point to 'worker's profile', 'specific measurements', and 'worker's work position'. At the bottom right, there are 'cancel' and 'save and close' buttons with corresponding icons.



user manual

The screenshot shows the 'add worker' window in the PLUX ERGO software. The window has a title bar with the PLUX logo and system icons. Below the title bar, there are two tabs: 'worker info' and 'antropometric measurements', with the latter being selected. The main content area is divided into two columns: 'general measures' and 'upper limbs'. The 'general measures' column includes input fields for height (cm), body mass (kg), sitting height (cm), geminal fold (cm), chest perimeter (cm), abdominal perimeter (cm), and geminal perimeter (cm). The 'upper limbs' column includes input fields for hand length (cm), arm length (cm), forearm length (cm), arm perimeter with contraction (cm), arm perimeter without contraction (cm), forearm perimeter with contraction (cm), forearm perimeter without contraction (cm), forearm fold (cm), and tricipital fold (cm). A callout box with the text 'insert the antropometric measurements' points to the input fields. At the bottom right, there are 'cancel' and 'save and close' buttons, each with a corresponding icon (a blue 'X' and a blue checkmark).

Besides the worker's basic profile information and registry of his antropometric measurements, you can edit the information about the work position.

It is advised to introduce the information of the current work position for each worker for future a comparison of occupational risk between work positions.



user manual

Select worker

In the worker's screen, you can start new protocols, see reports and edit the worker's profile.





user manual

Edit worker

The screenshot shows the 'edit worker' interface. On the left, the 'worker info' tab is active, showing fields for ID, name (Worker 1), surname, birthdate, sex (male/female), start in the company, and previous work positions. The 'antropometric measurements' tab is also visible. The main area is titled 'edit worker' and contains a 'Default Worker' field, a list of work positions (currently 'work1'), and a 'remarks' field. A photo of a worker is visible in the top right corner. Callout boxes highlight various features: 'a worker's photo can be added' points to the photo; 'delete work position' points to a trash icon; 'add work position' points to a plus icon; 'delete photo' and 'insert photo' point to photo management icons; 'next work position' points to a right arrow; and 'delete profile' points to a trash icon at the bottom right.

If the worker changes to other work position in the company, a new work position should be added in his profile. The evaluation sessions conducted in the context of the new work position will therefore be separated from those carried out in previous contexts.

Warning: if you delete a work position, all reports associated with it will be deleted. It is only possible to delete the last created work position until there is only one selected.

In the edit page a photo can also be added for a better identification of the worker.



user manual

Protocols



Clicking on the icon "protocols" gives you the list of evaluation protocols that can be executed. An evaluation protocol consists of a sequence of steps that the worker performs to ascertain its occupational risk level. Usually, the first steps of a protocol are calibration steps and / or preparation for the exercise (or exercises), which aims to re-educate the muscles. The evaluations should be conducted under the guidance of an ergonomist.

We provide a generic evaluation and an occupation-specific protocol: muscular load and exposure to vibration protocols.





user manual

System messages

During the protocol sessions, the software sends messages that informs about the bioPLUX device connection state. Messages are recorded by the software so that, in situations of failure, PLUX technicians can easily identify the type of occurrence.

The Plux device is not paired.

The messages appear at the bottom of the screen and can be:

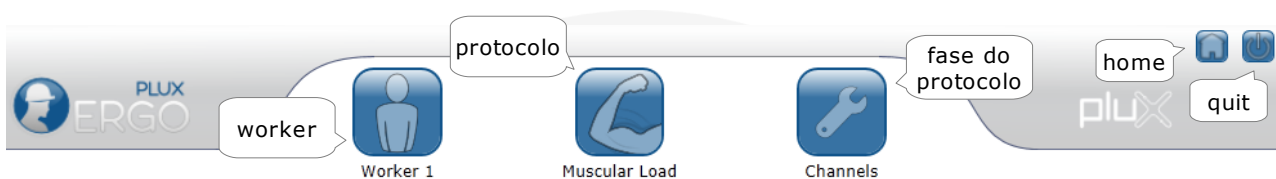
- "OK"
- "This application is not compatible with this version of the device bioPLUX"
- "Specified address is not correct. Verify that consists of six (6) alphanumeric characters separated by a colon (:) [xx:xx:xx:xx:xx:xx]"
- "The Bluetooth adapter was not found. Verify that an adapter is connected and turned on"
- "The device bioPlux was not found. Verify that you are within range, and that the battery is ok (red light off)"
- "The computer has lost contact with the device bioPlux. Verify that you are within range, on, and that the battery is ok (red light off)"
- "The communication port does not exist or is already in use"
- "The communication port can not be initialized. The supplied parameter cannot be changed"
- "The communication port is already open"
- "The device's firmware version is not supported"
- "The communication port is not open"
- "The bioPLUX device is not available"
- "The bioPLUX device is already in acquisition mode"
- "The bioPLUX device is not in acquisition mode"
- "The communication port can not be closed"
- "The bioPLUX device is not paired"
- "Invalid parameter"
- "invalid function"
- "Unknown error"



user manual

Session

All screens throughout the protocol have a header that identifies the protocol that is taking place, the worker and the current step of the protocol.



In addition to the identifying icons of the protocol, there is also the icon "home". By clicking on this icon, the protocol is canceled and returns to the start menu. Clicking on the icon or photograph of the user, the protocol is canceled and returns to the menu of the worker. By clicking on the icon of the identification protocol, this is canceled and returns to the menu of protocols.

Once completed a session of a protocol is completed, click the "confirm" to proceed to next step. If you wish to cancel a step and go to a previous step, click "cancel" to return to previous screen.

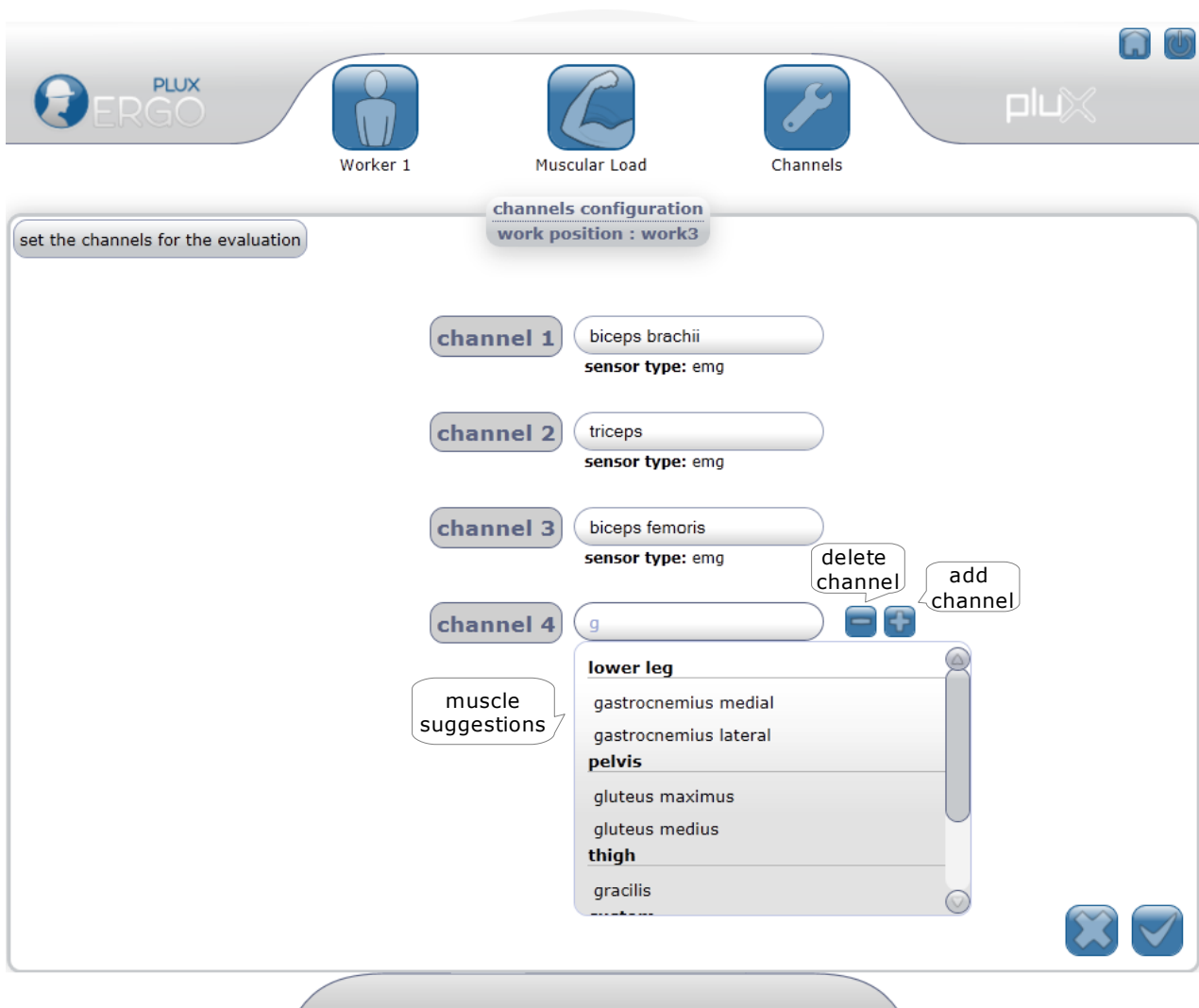




user manual

Muscular Load Protocol

For the muscular load protocol, the first page is for the ergonomist set the channels and corresponding muscles evaluated in that session. It is possible to choose up to 5 muscles in the same evaluation session.



The second page of the muscular load protocol is the maximum voluntary contraction session. After clicking the start button, each muscle should be activated separately or combined (depending on the protocol



user manual

defined by the ergonomist) and the results will be gathered after clicking the stop button. The results gathered are the maximum values encountered during the evaluation. It is advised to repeat the process three times so that a mean value of the measurements is used instead.

It is possible to delete an evaluation if there was a mistake in the measurement.

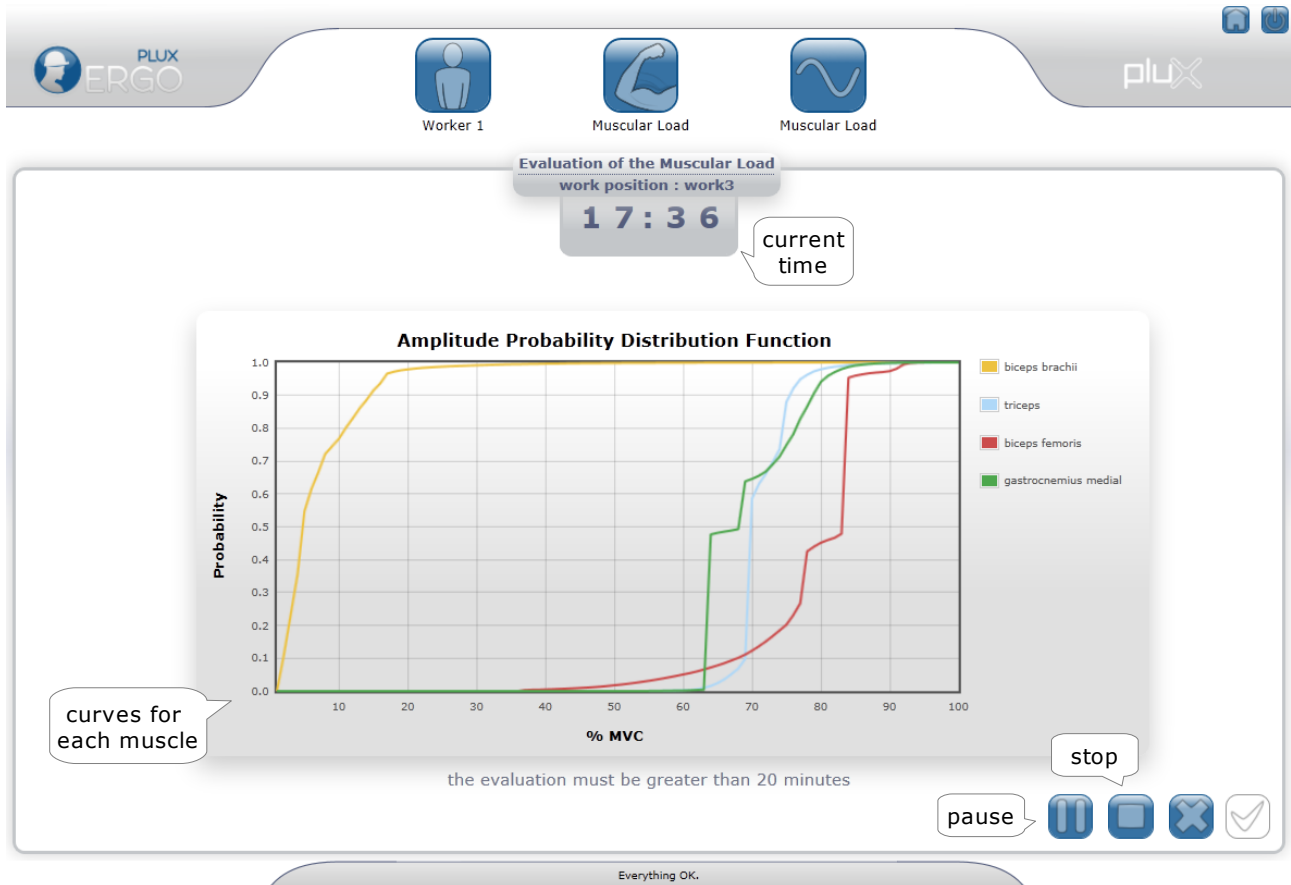


The next and last page of the protocol will assess the muscular load of the current task. A graphic with a line for each muscle is displayed and updated every 10 seconds to give feedback in real time to the ergonomist.

Warning: The minimum time of evaluation for this protocol is 20 minutes when evaluating a work that is repetitious. For types of work that aren't repetitious it is advised to make at least 1 hour of evaluation. No reports will be shown if the acquisition time is lower than 20 minutes.



user manual



Note: The values displayed in this graphic are merely illustrative.

It is possible to pause the acquisition and resume it when possible, or stop it and start a new one.

By clicking the confirm button, after stopping the evaluation, a report for that session will appear.



user manual

Exposure to Vibration Protocol

The exposure to vibration protocol is specific for occupations that use vibrating tools. It is necessary to choose if the tool affect the hand-arm system (hand handled tools) or the whole body (larger tools or vehicles). If the tool affects the whole body, it is also necessary to indicate if the worker is in a standing or a sitting position.

The exposure to vibration protocol is an evaluation that should be made for each tool used in a work day. Therefore, the number of hours spent using that tool in a normal work day (reference: 8 hours) must be introduced in the first page.

The screenshot shows the 'Tasks configuration' window in the PLUX ERGO software. At the top, there are three main navigation icons: 'Worker 1', 'Exposure to Vibration', and 'Tasks'. The 'Tasks configuration' window has a title bar with 'Tasks configuration' and 'work position : work3'. Below the title bar, there are two main evaluation options: 'hand - arm' (with a blue icon of a hand) and 'body' (with a green icon of a person). The 'body' option is selected, as indicated by a callout bubble 'evaluate whole body (selected)'. Below these options are 'remove task' and 'add task' buttons. A table below shows the configuration for two tasks:

task name	effective work time (hh:mm)	standing position
Task 1	00 : 20	standing position
Task 2	1 : 00	sitting position

Callouts for the table indicate 'Name of task/tool' for the task name column, 'time spent in a day' for the effective work time column, and 'standing position' and 'sitting position' for the position icons. A 'calibration configuration' button is located in the bottom left corner. The interface also includes a 'set the zone of evaluation' button in the top left and a 'plux' logo in the top right.



user manual

If it is the first time using the software, it is necessary to introduce the calibration values of the accelerometer sensor. Those values can be found in the card provided with the system.

The diagram illustrates the process of transferring calibration data from a physical card to the software. The card, labeled 'PLUX ERGO', contains the following information:

CHANNELS		CALIBRATION	
		MAX.	MIN.
1	X	932	624
2	Y	920	612
3	Z	966	632

Below the table, the MAC ADDRESS is listed as 00:07:80:4B:3F:5A. A speech bubble labeled 'calibration configuration' points to a software window titled 'accelerometer configuration'. This window features input fields for X, Y, and Z channels, each with 'MAX.' and 'MIN.' sub-fields. The X channel has a vertical line in its MAX. field. The window also includes a close button (X) and a checkmark button.

More information about the sensor's calibration and gain values are provided in the appendix of this manual (page 54).



user manual

In the page to measure the exposure to vibration two bars are presented: one with the value of the vibration for the current task/tool and other with the cumulative vibration value for all the tasks/tools.

By clicking the start button the evaluation will begin and the bars values are updated each 10 seconds. It is possible to stop the evaluation and start again, or stop it and go to the evaluation of the next task.

It is advised to make an evaluation of 1 to 5 minutes.

Warning: It is only possible to record the results and display the report if all the tasks selected before are completed.

placement of the sensor

Worker 1

Exposure to Vibration

Vibrations

PLUX ERGO

plux

Evaluation of vibrations daily exposure

work position : work3

00:54

current time

working position

1.15

0.5

current vibration

0.63

m/s² A(8)

current task

Task 2

current task exposure

1.25

cummulative vibration

1.25

m/s² A(8)

start

next task

Everything OK.



user manual

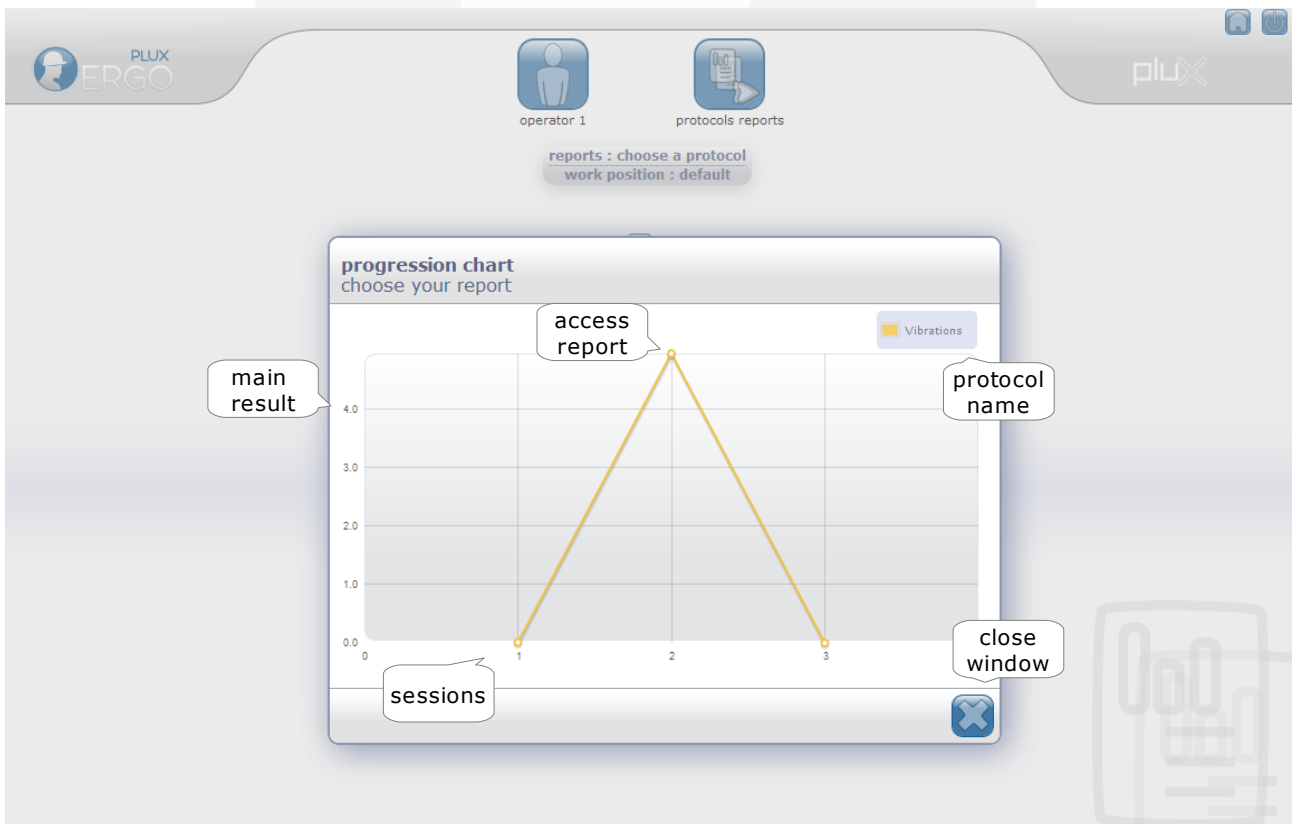
Reports



The screen "report" contains a list of protocols already made for a particular work position.



Clicking on the icon of a protocol accesses the worker's progression chart for this protocol. Each point on the graph corresponds to a different session. To see the date and time of the sessions, move the mouse over the respective point.





user manual

For the vibration protocol, the main result displayed in the progression chart represents the daily exposure to vibration value obtained after completion of a session for all the tasks.

For the muscular load protocol, the main result is a ponderation of the result values between 0 and 1. If the value is lower than 0.5, the worker doesn't present a risk tendency in any muscle. If the value is higher than 0.5, at least in one muscle present muscular load values higher than the advised.

To view the report of the session you want, simply click on the point, as specified in the figure above. You can then, if desired, edit the comments section of the report and print it.

The report contain the following information:

- worker's personal data
- identification of the protocol
- results
- comments (editable)
- name of the technician in charge (editable).

The screenshot displays the PLUX ERGO software interface. At the top, there is a header with the PLUX ERGO logo on the left and the PLUX logo on the right. The main content area is titled 'report' and is divided into several sections:

- about the evaluation:** This section contains two sub-sections:
 - Worker 1:** Labeled 'worker's information', it includes fields for ID, birthdate, and work position (work3).
 - Protocol - Muscular Load:** Labeled 'protocol's information', it includes 'evaluations' (with a graph icon), 'session date' (06-12-2011 14:28:11), and 'channels' (1 - biceps brachii, 2 - triceps, 3 - biceps femoris, 4 - gastrocnemius medial).
- results:** This section is labeled 'specific protocol results' and contains a table for 'Maximum Voluntary Contraction'.

The 'Maximum Voluntary Contraction' table is as follows:

	biceps brachii	triceps	biceps femoris	gastrocnemius medial
maximum	0.30 V	2.19 V	1.82 V	2.14 V
mean	0.28 V	2.09 V	1.71 V	1.94 V

At the bottom of the interface, there are two buttons: 'delete report' on the left and 'print report' on the right.



user manual

comments

add a comment
to the report

insert name
of the ergonomist

ergonomist





user manual

Muscular Load Report

In the muscular load report, the values for the maximum voluntary contraction are provided and the curves obtained for each muscle are displayed separately and combined. In each graphic the risk values inherent to the evaluation of the muscular load of a specific muscle are displayed. This risk values are collected from the 0.1, 0.5 and 0.9 percentile of the amplitude probability distribution profile. The reference and standard values are:

0.1 percentile:

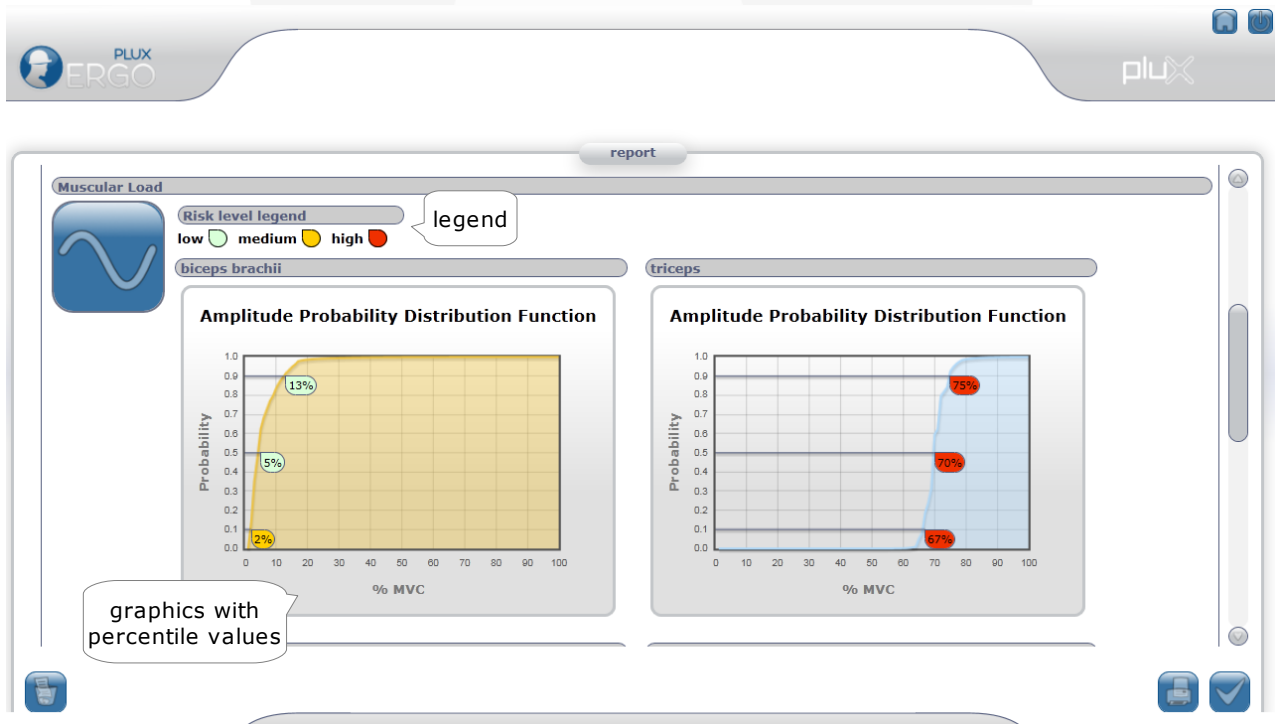
low risk: 0-2%
medium risk: 2-5%
high risk: 5-100%

0.5 percentile:

low risk: 0-10%
medium risk: 10-14%
high risk: 14-100%

0.9 percentile:

low risk: 0-50%
medium risk: 50-70%
high risk: 70-100%





user manual

Exposure to Vibration Report

In the exposure to vibration report, bars are presented with the results for each task individually and a graphic with the vibration vs effective working hours is given for the daily exposure to vibration value.

The standard risk values for hand-arm and whole body evaluation of vibration are:

hand-arm system:

exposure action value: $2.5 \text{ m/s}^2 \text{ A}(8)$

exposure limit value: $5 \text{ m/s}^2 \text{ A}(8)$

whole body system:

exposure action level: $0.5 \text{ m/s}^2 \text{ A}(8)$

exposure limit level: $1.15 \text{ m/s}^2 \text{ A}(8)$





user manual

Chapter 4: Information about safety, support and quality

Classification and identification



In accordance with the Decree-Law N° 273/95 of 23 October.
Device Class I with measuring function, Annex VII.



Internally powered equipment (IEC 60601-1). Class II device when connected to external power supply (IEC 60601-1).



Device with applicable parts of the type BF (IEC 60601-1).



Non-ionizing electromagnetic radiation. The device includes radio frequencies transmissions likely to cause interference with other equipment.

SN

Serial number (affixed to the bioPLUX clinical device).

Contraindications



Do not use this device in workers with implanted electronic devices of any kind, including pace-makers, electronic infusion pumps, stimulators, defibrillators or similar.



Do not apply electrodes over damaged skin.



Do not use the system in workers with allergies to silver.



user manual

Warnings



See all the documentation that came with the system for instructions on safety and precaution.



See the User's Guide for detailed instructions about bioPLUX and sensors.



Always keep the device and its accessories dry. The presence of liquid contact can compromise the safety operating characteristics of the system.



Fragile. Handle with caution. Do not expose the device or accessories to high accelerations and vibrations.



In compliance with the European Directive on Waste of Electrical and Electronic Equipment (WEEE) 2002/96/EC, do not deposit the bioPLUX in the trash. Instead, contact your Reseller or PLUX for properly recycle your bioPLUX. You can get information about the contact nearest to you in <http://www.plux.info>.



The bioPLUX device should be used at temperatures between 10° and 40°C and stored at temperatures between 10° and 30°C because it has rechargeable Li-Ion batteries and detection surfaces with limitations on operating temperatures. Operating or storing the device outside this range may compromise the integrity and security of it.



Do not use this equipment in an environment with operating magnetic resonance imaging devices (MRI).



Do not use the device near the fire or in potentially explosive atmospheres, such as atmospheres with flammable gas.



The use of damaged accessories or not recommended by PLUX may result in changes to the technical characteristics and features of your bioPLUX. Use only approved accessories purchased from PLUX or an PLUX agent.



user manual



Use only the detection surfaces provided on the packaging of the system or acquired from PLUX or an PLUX agent.



The detection surfaces provided are single-user and disposable.

Use only the transformer supplied with the package of the system or purchased from PLUX or an PLUX agent.



Inspect the sensors on a regular basis to ensure that they remain in good working order.



If you experience any kind of discomfort or skin irritation when using the clinical bioPLUX, discontinue using it immediately.



The bioPLUX should not be used continuously for periods of time above 60 minutes.



Do not place the device in the microwave.



If the bioPLUX system or accessories reach uncomfortable temperatures, turn off the bioPLUX immediately and contact Technical Support.



Do not insert objects into the holes of the device, it may affect the operating characteristics, and safety.



Do not open the bioPLUX or its accessories. The repair of the same should be only done by properly authorized PLUX personnel.



By connecting the bioPLUX to the transformer for batteries recharge, place the device so that the cable is free, away from places where it can be walked on or damaged. Make sure the cable does not obstruct the passage of people.



Use the sensor cables with extreme caution to avoid risk of strangulation.



user manual



The bioPLUX may suffer or cause interference to other equipment with radio receiver / transmitters, even those that comply with international standards. Keep a safe distance between the bioPLUX and other devices to ensure their proper functioning.



This equipment complies with International Standard EN 60601-1-2:2001 for electromagnetic compatibility for medical equipment and systems. This pattern is used to provide reasonable protection against harmful interference in a typical medical environment. However, the proliferation of devices using radio frequencies can cause interference that can reach the limit to prevent the proper functioning of your bioPLUX. Keep your medical equipment installed in accordance with their instructions.



If your bioPLUX stops working properly, do not use it until you send it for repair by qualified PLUX personnel.



Use bioPLUX within the limits of communication with the receiving equipment of the wireless signal: in a radius of approximately 10 meters for the Bluetooth connection. Working with the device outside of this range of communication can lead to data loss and faulty communications.



Exposure to radio-frequency.

The bioPLUX clinical radiation emission levels are in accordance with the limits of exposure to radiation allowed by the FCC (transmission module with FCC ID:QoQwT12). Nevertheless, the device must be used in a way to minimize human contact during normal operation. Use the bioPLUX clinical only for the necessary period of time.



The bioPLUX should not be used in noisy environments in relation to RF radiation which can cause communication failures with the computer.



Do not immerse the sensors or the bioPLUX, nor clean with liquid or with abrasives. Read the manual to learn how to clean up the bioPLUX and sensors.



user manual

Electromagnetic emissions

See the table below for specific information regarding the bioPLUX electromagnetic emissions.

<i>The bioPLUX is intended for use in the electromagnetic environment specified below. The client and / or user of this device should ensure that it is used in such an environment.</i>		
Emissions test	Compliance	Electromagnetic Environment - Guidance
RF Emissions CISPR 11	Group 1	This device must emit electromagnetic energy in order to perform its function. Electronic equipment near it, may be affected.
RF Emissions CISPR 11	Class B	This device is suitable for use in all establishments, including domestic and those directly connected to low-voltage energy public network supply which supplies buildings used for domestic purposes.
Harmonic Emissions IEC 61000-3-2	A	
Voltage fluctuations / Flicker Emission IEC 61000-3-3	conforms	

Table 1: Electromagnetic Emissions



user manual

Maintenance recommendations

Cleaning

- the bioPLUX equipment and sensors should be visually checked before each use to ensure that no mechanical damage has occurred.
- the bioPLUX equipment and sensors (including the cables) should be cleaned with a slightly damp cloth or suitable absorbent paper, ensuring that no liquid enters the equipment or sensors. Do not use detergent or any type of cleaning liquid.
- Clean the bioPLUX equipment separately from the sensors
- Do not clean or re-use detection surfaces. They are only suitable for single use, and should be disposed of after usage.

Transport and storage

- When the equipment and accessories are not being used, they should be stored in the original box in a dry place:
 - Relative humidity: up to 95% with no condensation
 - Ambient temperature: 10°C to 30°C
 - Atmospheric pressure between 500 hPa 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 bag and avoid dropping it, since the device is not shock-proof and should not be placed under stress or sudden acceleration.

PLUX can not be held responsible if the system is transported outside it's original box or in any other type of unsuitable packaging, which may invalidate the guarantee.



user manual

Technical specifications

bioPLUX device



Wireless Connectivity, via bluetooth with range of 10m. Class 2 Bluetooth



8 analogical channels at 12 bit with 1000Hz sampling



1 digital port 1 bit I/O



Weight **86g**



Dimensions: **84 mm x 53 mm x 18 mm**

Charger

FW7600/09 charger with universal battery



Input 100 to 240 V~, 50 to 60 Hz, 90 mA



Output 9 V, 360 mA



Conforms with **IEC 60950**



user manual

Bluetooth adapter



Compatible with USB 1.2



Bluetooth High speed 3Mbps



Range of 5m for signal reception



Security

parity, encryption and authentication



user manual

Technical assistance

PLUX provides Technical Assistance for all the equipment it supplies, and damaged parts, accessories or bioPLUX devices may be substituted or repaired.

Technical Assistance is provided at PLUX's premises.

Even if the system is under guarantee, before calling a Technician please carry out a few simple checks to see if the problem can be solved without requesting support. See if following questions help in resolving the matter. If you are unable to solve the problem, contact PLUX technical support:

email: support@plux.info

phone number: +351 211 956 542

1. I started the biofeedback software, connected the bioPLUX device and the sensors, but no signal appears on the monitor.

Before taking any action, make sure that any error messages appeared at the bottom of the screen and, if so, what is the message. Some messages are self-explanatory and can help you resolve your problem. If you can not solve the problem, disconnect the device, restart the software and reconnect the device.

2. The bioPLUX is switched on but it does not work. What should I do?

Check to see whether the battery is low or needs charging. Autonomy is approximately 12 hours. If the battery is low, recharge it (see page 15). If, after recharging without problems (see bioPLUX device statuses on page 10), the device still does not work, please contact PLUX technical assistance.

Note: the bioPLUX cannot be used while recharging.

3. The bioPLUX is recharging and, after a time, a red light turned on (in status). What does it mean?

A stable warning light means that an error occurred during recharging the bioPLUX device (see page 10). Disconnect the bioPLUX from the transformer and connect it again, to finish the recharging process, as



user manual

described on page 15.

4. How to check the progress and the previous reports of a particular worker?

Initially, select the user from the list of workers, then select the "Reports" button. If the user has performed more than a protocol, select the protocol that you want to view in the user's progress, and there will be a graphic illustration of progress between sessions. You can then select a specific point on the graphic, which means a report. See more at page 38.

Guarantee of quality

The ergoPLUX system for occupational risk assessment has a two year quality guarantee from the date of purchase.

PLUX guarantees that the hardware, accessories and PLUX software will be free from material or manufacturing defects for two years 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.

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 this guarantee.



user manual





user manual

Calibration Sheet

The triaxial accelerometers distributed by PLUX have to be calibrated every year. PLUX offers to calibrate the sensors free of charge for the first two years following request. For more information contact the PLUX technical support:

email: support@plux.info

phone number: +351 211 956 542

The ergoPLUX system purchased has an accelerometer sensor which is sent already calibrated. The calibration values are inserted in the card provided with the system and should be inserted into the software accordingly (as explained in page 36).

CHANNELS		CALIBRATION	
		MAX.	MIN.
1	X	932	624
2	Y	920	612
3	Z	966	632

MAC ADDRESS
00:07:80:4B:3F:5A

The following pages will detail more information about the sensors used: xyzPLUX and emgPLUX.

Description

Plux offers a triaxial accelerometer based on MEMS® (Micro Electro-Mechanical Systems) technology and has been developed for biomedical applications where cinematic and motion measurements are required. This sensor can measure accelerations relative to free fall and the model available is capable of detecting magnitude and direction of this same acceleration, as a vector quantity. This resulting vector can then be used to sense position, vibration, shock, fall, etc. Attaching the accelerometer to a limb for example, an acceleration can be measured within the dynamic range of the sensor.

xyzPlux triaxial accelerometer sensor presents itself robust, stable, accurate, low cost, with a dynamic range of $\pm 3g$ and due to its small size, its integration is very easy.



Figure 1: xyzPlux Triaxial Accelerometer

Applications

Nowadays accelerometers are widely spread from areas so distinguished as engineering, biology, building monitoring, biomechanics, etc, even cell phones and gaming consoles have them. Vibration measurements, particularly in research applications and studies of bodydynamic and biomechanic analysis are the perfect context candidates to use our compact MEMS® triaxial accelerometers.

Plux triaxial accelerometer sensors are designed for applications involving continuous or intermittent accelerometry readings in patients. Depending on the application it may require an acquisition system with up to 3 available analog ports in order to use the full measurement functionalities. For biaxial and uniaxial applications this same sensor can be used.

Characteristics of Plux triaxial accelerometer sensors

The xyzPlux accelerometer sensor characteristics are described in Figure 2 and Table 1. Depending on the application it may require an acquisition system with up to 3 available analog ports in order to use the full measurement functionalities.

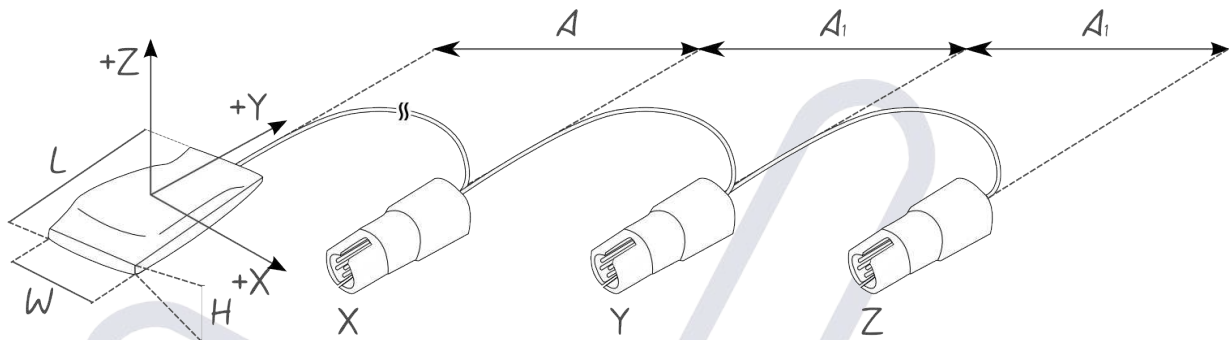


Figure 2: Typical sensor model

xyzPlux accelerometer sensor				
Parameter	Min	Typ	Max	Units
Sensing axis	-	3	-	#
Measurement full scale range	± 3	± 3.6	-	g
Nonlinearity (% of full scale)	-	± 0.3	-	%
X, Y and Z axis bandwidth (-3dB)	432	500	585	Hz
Single Supply Voltage	1.8	2.5	3.6	V
Current consumption	260	280	300	μA
Operating Temperature	-35	-	+85	$^{\circ}\text{C}$
Sensor width (W)	-	9 ± 1	-	mm
Sensor length (L)	-	21 ± 2	-	mm
Sensor height (H)	-	4 ± 1	-	mm
Cable length (A)	-	100 ± 5	-	cm
Sub cable length (A1)	-	15 ± 1	-	cm
Wire type	-	36AWG	-	NA
Wire isolation	-	PFA (PerFluoro Alkoxy)	-	NA
Body material	-	Molded Rubber	-	NA

Table 1: xyzPlux sensor characteristics

Calibration procedure for the xyzPlux accelerometer

Calibrating the xyzPlux sensor is a very important step to obtain the best results and use the whole dynamic range of the sensor. To complete the calibration successfully, there are some hardware and software requirements that must be prepared. More precisely a xyzPlux sensor, a bioPlux acquisition unit, a Bluetooth dongle, a computer with Monitor Plux software installed and a software that allows some simple mathematical operations (Python, MatLab, Excel, etc).

In the next steps, the calibration procedure will be described:

1. To start with, the user must connect the three axis of xyzPlux sensor to a bioPlux acquisition unit. The The Bluetooth dongle must be connected to a USB port and Monitor Plux must be in ready state to make an acquisition;
2. For this calibration process, it's important to know in which bioPlux channel the X, Y and Z axis are connected. In Figure 3 a connection diagram is suggested;



Figure 3: xyzPlux suggested connection

3. Taking into account Figure 4 and the represented axis orientation, start an acquisition and slowly make a roll movement as shown in Figure 5. This rotation movement should at least complete 180°;

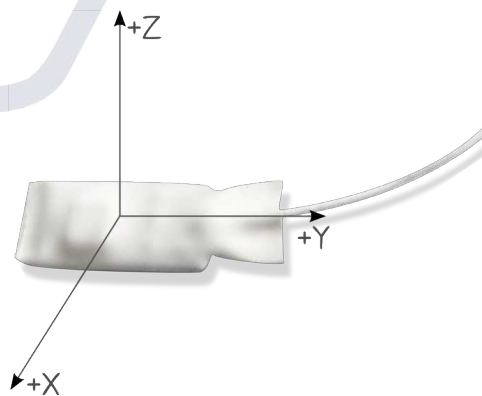


Figure 4: xyzPlux axis orientation

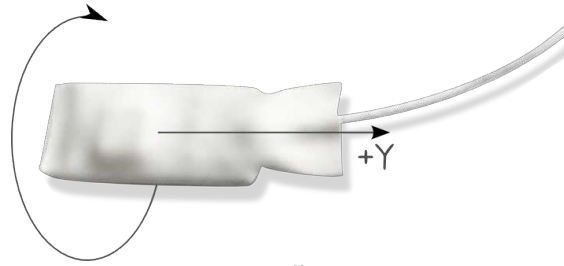


Figure 5: Roll movement

- After the roll movement is complete and within the same acquisition session, a pitch movement must be made as shown in Figure 6. This rotation movement should at least complete 180°;

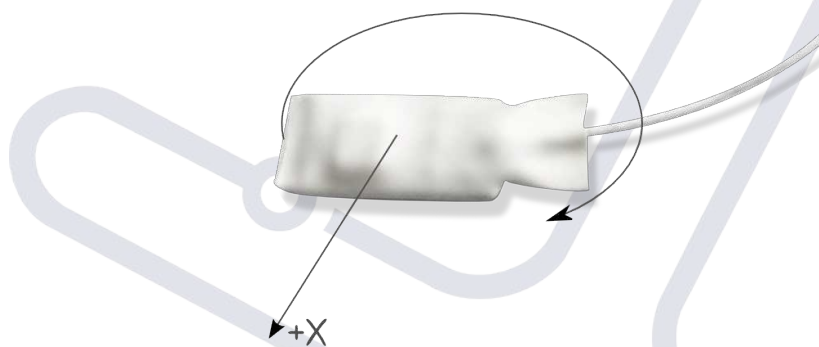


Figure 6: Pitch movement

- During the roll and pitch rotations, abrupt movements should be avoided or minimized and only one axis should be rotated at a given moment. The objective of this procedure is to align X and Y axis with gravity vector;
- The acquisition session collected by Monitor Plux, must now be saved in a text file. As an example, an excerpt of the file created by Monitor Plux is shown below;

```

# bioPlux Text File Format
# Version: 1
# StartDateTime: 2010-02-25 10:50:58
# SamplingFrequency: 1000
# SampledChannels: 1 2 3 4 5 6 7 8
# SamplingResolution: 12
# AcquiringDevice: 00:07:80:89:3A:6B
# EndOfHeader
0      0      0      770      740      934      0      0      0      0      0
1      0      0      770      740      934      2      0      0      0      0
2      0      0      770      740      934      1      0      0      0      0
3      0      0      769      741      933      1      0      0      0      0
4      0      0      768      742      934      1      0      0      0      0
5      0      0      769      742      934      1      0      0      0      0
6      0      0      769      742      933      1      0      0      0      0
7      0      0      769      742      933      1      0      0      0      0
8      0      0      769      743      932      0      0      0      0      0
9      0      0      769      743      933      0      0      0      0      0

```

- Using a software that allows mathematical operations, maximum and minimum values for each one of the three axis must be searched in the saved file. In other words, after this step there must be six values corresponding to X_{MIN} , X_{MAX} , Y_{MIN} , Y_{MAX} , Z_{MIN} and finally Z_{MAX} ;

8. The calibration is complete and the six values, which must be saved, will be used in the conversion of magnitudes addressed ahead in the text. This procedure doesn't need to be done every time the xyzPlux accelerometer sensor is used. It's enough to calibrate once, each time a new sensor or new bioPlux is used is connected to the bioPlux device.
9. CodeBox 1 shows a Python example on how to find the minimum and maximum for vector values of the x-axis using a smooth filter:

```

# Imports
from scipy import *
from numpy import *

file = loadtxt('CalibrationSequence.txt',usecols=(3,4,5))

Sgn_X = file[:,0]
Sgn_X_max =max(smooth(Sgn_X>window_len=100>window='hanning'))
Sgn_X_min = min(smooth(Sgn_X>window_len=100>window='hanning'))

X_Cal = [Sgn_X_max, Sgn_X_min]

```

CodeBox 1: Minimum and maximum - Python example for x-axis

Calculation of g-force from bioPlux digital values

The conversion of the bioPlux collected values in gravity force is done by using the equations (1.1) and (1.2). The given equations were individualized for the X axis. For the other two remaining axis, the equations are the same. In equation (1.1), V_{MAX_x} refers to the X axis maximum values, V_{MIN_x} refers to the X axis minimum values, both previously calculated. $Signal_x$ refers to the respective row of raw values acquired by bioPlux and saved in a text file in Monitor Plux.

$$V_{MEAN_x} = \frac{V_{MAX_x} + V_{MIN_x}}{2} \quad (1.1)$$

$$g_x = \frac{signal_x - V_{MEAN_x}}{V_{MAX_x} - V_{MEAN_x}} \quad (1.2)$$

If the accelerometer is at rest, and the plane formed by X and Y axis is horizontal, the values in g's obtained for X and Y must be very close to 0g. The Z axis, depending if the sensor is facing up or down, the obtained values will be +1g or -1g approximately. CodeBox 2 shows an example in Python where a conversion is made for the x-axis.

```

# Imports
from scipy import *
from numpy import *
#-----
# Funtions
def convertV2G(signal, vmin, vmax):
    vmean = (vmax+vmin)/2
    v_g = (signal-vmean)/(vmax-vmean)
    return v_g
#-----
file = loadtxt('MovementSequence.txt',usecols=(3,4,5))

Sgn_X = file[:,0]

# Load Calibration values already calculated
Vmin_X = X_Cal[0]
Vmax_X = X_Cal[1]

# Conversion
Sgn_X_G = convertV2G(Sgn_X, Vmin_X, Vmax_X)

```

CodeBox 2: Accelerometry conversion - Python example for x-axis

Ordering Guide and final notes

The accelerometer model is designed to be interchangeable within the interval of -35°C to +85°C. For a better overall stability, the storage and work temperatures should be maintained below +70°C.

xyzPlux – XXXX – X

Number of sensing axis: 3

Type:

01ACEL – Series01; Perfluoro Alkoxy cover 36 awg; Molded rubber isolation

Description

Muscular movement involves the action of muscles and nerves and needs a very small electrical current. Measuring the electrical activity in muscles and nerves can help find diseases that damage muscle tissue, find the cause of weakness or paralysis.

Plux offers emgPlux, a sensor capable of performing electromyography measurements that uses bipolar surface electrodes and monitors the muscle activation, as opposed to the activity of only a few fibres as observed using an intramuscular EMG. This technique is used for evaluating and recording the electrical activity produced by muscles in a number of settings. For example, in a physiotherapy session, muscle activation is monitored using surface EMG and patients have an acoustic or visual stimulus to help them know when they are activating the muscle (biofeedback).



Figure 1: emgPlux sEMG Sensor

With bipolar configuration, two detection surfaces are used to detect the electrical potentials in the muscular region of interest with respect to a reference electrode, which should be placed in a region of low muscular activity. The result is the amplified difference between these two signals, which eliminates the common unwanted signals detected by both surfaces. Since all the fibers in the recording area contract at different rates, the signal detected by the sensor is a constantly varying difference of potential between the two electrodes, and because the motor electrical stimulus travels from the brain to the muscle, there is a time delay of 50ms to 100ms between the sEMG signal and the movement.

Applications

Surface electromyography (sEMG) is a technique which is used in many clinical and biomedical applications, in areas like neurology, rehabilitation, orthopedics, ergonomics, sports, etc. sEMG is used as a diagnostics or biofeedback tool for identifying neuromuscular diseases allowing clinicians to assess patients' magnitude and time patterns of muscle activity. Tests of muscle fatigue, disorders of motor control and assessing low-back pain are also important applications of emgPlux.

Sensing isometric muscular activity where no movement is produced enabling a definition of classes of subtle motionless gestures to control interfaces without being noticed and without disrupting the surrounding environment. These signals can be used to control signals for prosthetic devices such as prosthetic hands, arms, and lower limbs or as a control signal for an electronic device such as a mobile phone or PDA. sEMG recordings may also be a suitable control signal for some interactive video games. The range of applications of emgPlux are immense.

Characteristics of emgPlux EMG sensors

In biofeedback therapy patients are often restrained by pain and/or fear. It is crucial that the medical instruments do not introduce additional constraints that limit the effect of the therapy. EmgPlux sensors are created with these constraints and needs in account and use flexible and light cables, which are more comfortable to the patient and, as a consequence, allow for a greater freedom of movements. Light weighted, reduced size and wireless acquisition systems as emgPlux and bioPlux, allow for biofeedback work in clinical environment as well as at home during the patient's daily routines. These systems improve the functionality of the therapy in progress because the influence of the medical apparatus on movement is minimized and at the same time the signal acquisitions are made during real scenes. The emgPlux characteristics are described in Figure 2 and Table 1.

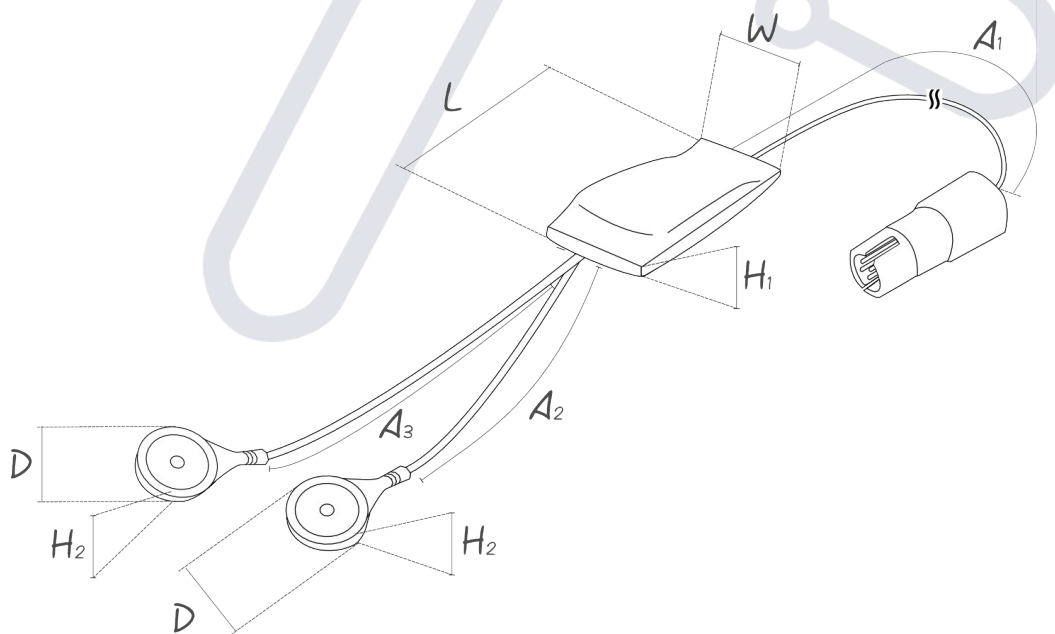


Figure 2: EmgPlux EMG sensor model

emgPlux EMG sensor				
Parameter	Min	Typ	Max	Units
Gain	-	1000	-	NA
Bandwidth (-6dB)	25	-	500	Hz
CMRR	-	110	-	dB
Input Impedance	-	>100M	-	Ω
Current consumption	0.95	-	1.01	mA
Operating Temperature	-35	-	+85	$^{\circ}\text{C}$
Sensor width (W)	-	10 ± 0.2	-	mm
Sensor length (L)	-	26.1 ± 1	-	mm
Sensor height (H1)	-	3.95 ± 0.5	-	mm
Cable length (A1)	-	100 ± 5	-	cm
Sub cable length (A2)	-	2.5 ± 0.5	-	cm
Sub cable length (A3)	-	5 ± 0.5	-	cm
Snap diameter (D)	-	14.6 ± 0.2	-	mm
Snap height (H2)	-	6.2 ± 0.1	-	mm
Wire type	-	36AWG	-	NA
Wire isolation	-	PFA (PerFluoro Alkoxy)	-	NA
Body material	-	Molded Rubber	-	NA

Table 1: emgPlux sensor characteristics

Our miniaturized sEMG active sensors have low noise characteristics that allows them to be used in the most adverse conditions of EMG acquisition. The amplification and signal conditioning elements placed near the acquisition area maximizes the sensors performance and final signal quality.

Acquisition, conversion example and transfer function of emgPlux EMG sensors

The process begins with the user making an acquisition with one of emgPlux EMG sensors and bioPlux. When finished, the acquisition session must be saved with Monitor Plux in a text file.

The bioPlux system acquires all sensor signals with a voltage range between 0 and 5 Volts, as can be seen in Figure 3. 0V corresponds to the digital value 0, and 5V corresponds to the digital value 4095 (an unsigned 12-bit integer). A variation in these digital values, corresponds to an analog signal voltage variation at the bioPlux inputs. The next step is to know the physical meaning of the signal voltages. To do this, the transfer function must be known, for of each type of sensor.

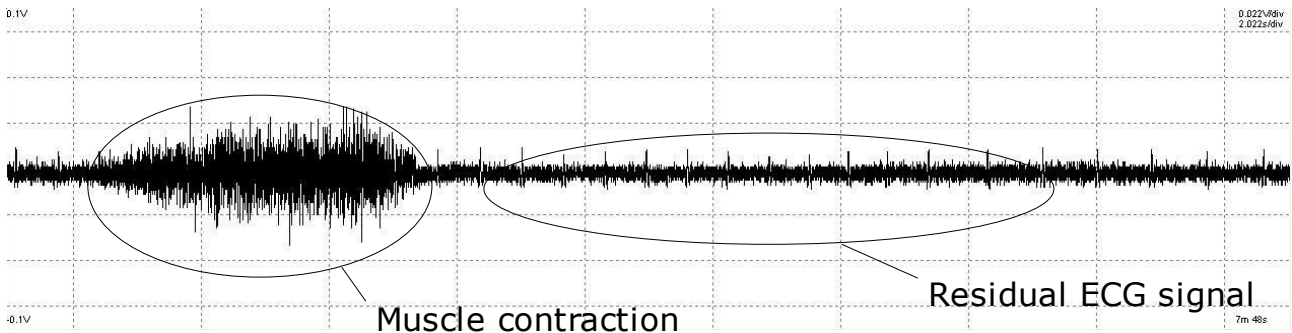
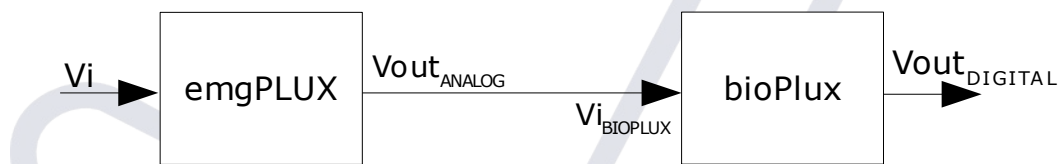


Figure 3: EMG signal acquisition example with emgPlux and Monitor Plux

The half-scale of the EMG sensor (absence of EMG signal) is about $5V / 2 = 2,5 V$ (0V in Monitor Plux), or a digital value of about $4096 / 2 = 2048$. The voltage gain of this sensor (i.e., the ratio between the output signal for the bioPlux and the input EMG signal) is 1000. The diagram and equations (1.1) and (1.2) follow this line of thinking:



$$V_{out_ANALOG} = V_{i_BIOPLUX} = V_i \times 1000 + 2.5 \quad (1.1)$$

$$V_{out_DIGITAL} = \frac{V_{out_ANALOG} \times 4096}{5} \Leftrightarrow V_{out_ANALOG} = \frac{V_{out_DIGITAL} \times 5}{4096} \quad (1.2)$$

Figure 3 shows an EMG signal acquisition example where two important events are represented. The first and most relevant event is the muscle contraction. The second event is dependent on the location of the muscle being measured and for this example in particular, the emgPlux electrodes were purposely placed close to an artery. Sometimes an ECG signal is also acquired because the heart is also a muscle.

Ordering Guide and final notes

The emgPlux model is designed to be interchangeable within the interval of $-35^{\circ}C$ to $+85^{\circ}C$. For a better overall stability, the storage and work temperatures should be maintained below $+70^{\circ}C$.

emgPlux – XXXX

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Type:

01EMG – Series01; Perfluoro Alkoxy cover 36 awg; Molded rubber isolation