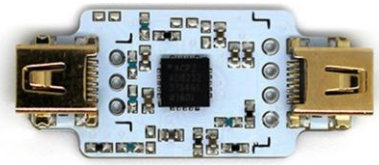
Electromyography (EMG) Sensor User Manual



ATTENTION
Please read this datasheet before
using your BITalino sensor

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Please check your systems and sensors after receiving and before using it the first time to confirm if it contains all the ordered sensors, accessories and other components. Contact our support via e-mail at support@plux.info if there are any variations from your original order.

For regulatory information, please see the Regulatory Disclaimer at the end of this document.

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v.1.0

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1. General Information

1.1. General Description

The BITalino Electromyography (EMG) is a purpose-built sensor to measure muscle activity. Our sensor is especially designed for surface EMG and works both with pre-gelled and most types of dry electrodes. The bipolar configuration is ideal for low-noise data acquisition, and the raw data output enables it to be used for human-computer interaction and biomedical projects alike.

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

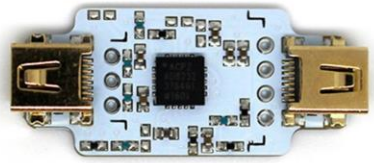


Figure 1: BITalino Electromyography (EMG) sensor (standard version).

1.2. Typical Unfiltered Sensor Output

Figure 2 shows a typical unfiltered EMG sensor output acquired along the muscle of the biceps brachii while two muscular contractions are performed over a time of 10 seconds. The raw digital sensor values received from the BITalino device ranged between 0 and 2^n-1 (n=sampling resolution) were converted into the original unit of measurement of this sensor (mV) using the transfer function found in section Transfer Function (Conversion Formula).

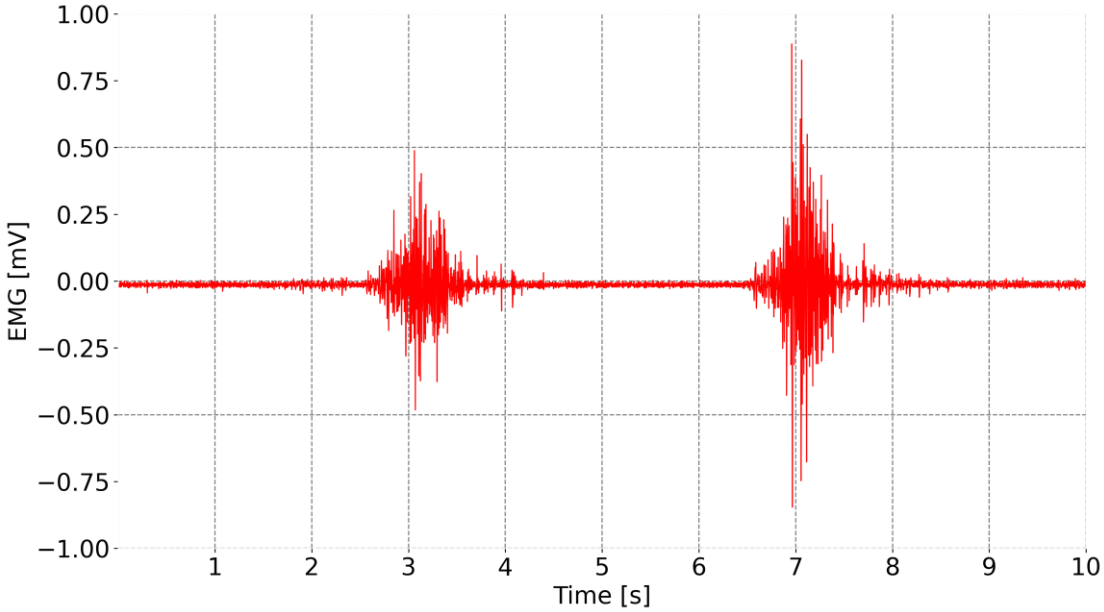


Figure 2: Typical unfiltered sensor output (signal acquired from the biceps while flexion of elbow and forearm in supination).

1.3. Sensor Specifications

> Gain:	1009	**> Range:**	±1.64mV (@VCC=3.3V)
> Bandwidth:	25-482Hz	**> Consumption:**	~0.17mA
> Input Impedance:	10/7.5 GOhm/pF	**> CMRR:**	86dB
> Input Voltage Range:	2.0-3.5V		

1.4. Features

> Bipolar differential measurement
> Pre-conditioned analog output
> Raw data output
> 3- or 2-lead electrode cable operation (only one REF is needed when using multiple EMGs)
> High signal-to-noise ratio
> Small form factor
> Easy-to-use

1.5. Applications

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

1.6. Transfer Function (Conversion Formula)

The analog sensor signals acquired with BITalino devices are converted into digital values ranged between 0 and 2^n-1 (n=sampling resolution, usually 6-bit or 10-bit) and streamed in the raw digital format.

In most applications, the original physical unit of the acquired EMG signal is preferred or required. The raw digital sensor samples can be converted back into millivolt (mV) using the following formulas:

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

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

Valid sensor range: [-1.64mV, 1.64mV]

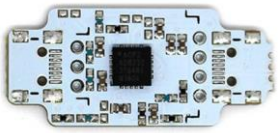
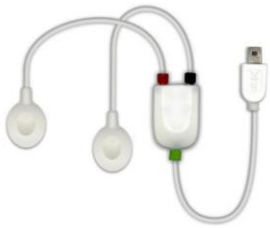
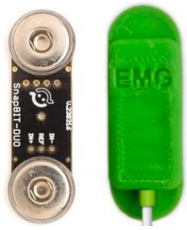
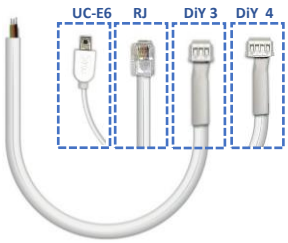
with:

$EMG(V)$	EMG signal in Volt (V)
$EMG(mV)$	EMG signal in milli-Volt (mV)
ADC	Value samples from the sensor/channel (digital value)
n	Sampling resolution (default: 10-bit resolution (n=10), although 6-bit may also be found)
VCC	Operating voltage (3.3V when used with BITalino)
G_{EMG}	Sensor gain (1009)

1.7. Electrode Connections & Sleeve Color Meanings

The BITalino EMG sensor can be connected to electrode cables and open wire cables with different connection types, see Table 1.

Table 1: Possible connection types for the EMG sensor.

Connection Type	**Self-assemble (none) / DiY (Molex Sherlock)**	**UC-E6**	**Assembled**
			
Electrode Cable	2-/3-lead Self-assemble / DiY (10cm / 30cm)	2-/ 3-lead (UC-E6) (10cm / 30cm)	Assembled SnapBITduo
		 	
Open wires Cable	Self assemble + DiY / UC-E6 / legacy (RJ) (10cm / 30cm / 100cm)	UC-E6 (10cm / 30cm / 100cm)	Assembled 1 x UC-E6 (100cm)
			

The sleeve color meaning for the 2- and 3-lead electrode cables for the UC-E6 sensor connection version are described in Table 2.

Table 2: Sleeve color meanings for UC-E6 connection.

Sleeve Color	Red	Black	White
Electrode Cable 2-lead	+	-	/
Electrode Cable 3-lead	+	-	reference

See section *2 Application Notes* for more information on where to place the electrodes and to connect electrodes cables for EMG acquisitions.

1.8. Physical Characteristics

The BITalino EMG sensor comes in a size of 12mm x 27mm (see Fig. 3).

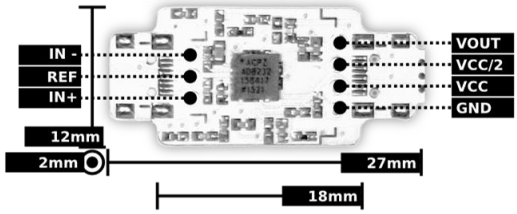


Figure 3: Physical characteristics of the standard BITalino EMG sensor.

2. Application Notes

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

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

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

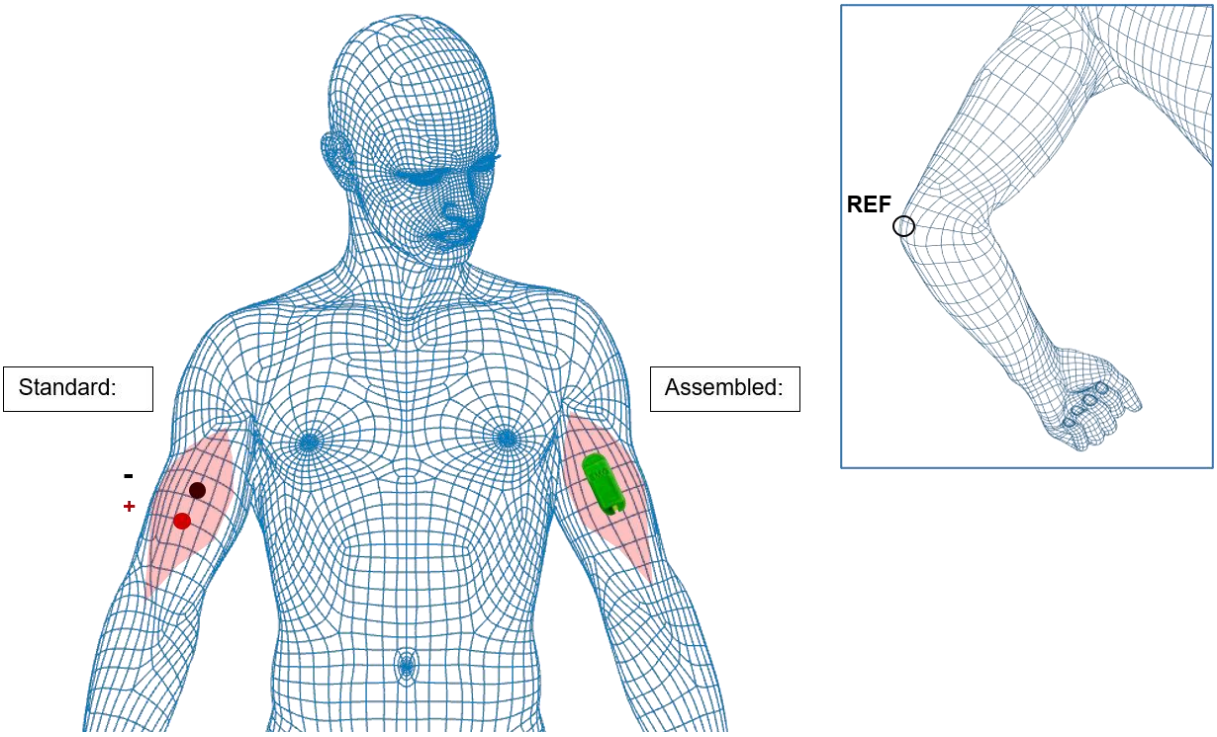


Figure 4: EMG electrode positioning at the muscle biceps brachii (marked in red) for standard version I (left) and assembled V (right), reference position (elbow).

Possible electrode positions are listed in Table 3. The positive and the negative measuring electrodes can be positioned in either way but along the muscle fibre and on the muscle belly. The reference electrode must always be positioned on a bone.

Table 3: Possible electrode positions for the standard and assembled version.

	Positive Electrode (+) (red sleeve)	Negative Electrode (-) (black sleeve)	Reference Electrode (white sleeve)
I (3-lead)	**Muscle placement 1**	**Muscle placement 2**	**Bone**
II (3-lead)	**Muscle placement 2**	**Muscle placement 1**	**Bone**
III (2-lead + REF)	**Muscle placement 1**	**Muscle placement 2**	**Bone**
IV (2-lead + REF)	**Muscle placement 2**	**Muscle placement 1**	**Bone**
	Positive Electrode (+)	**Negative Electrode (-)**	
V (assembled + REF)	**Muscle placement 1**	**Muscle placement 2**	**Bone**
VI (assembled + REF)	**Muscle placement 2**	**Muscle placement 1**	**Bone**

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

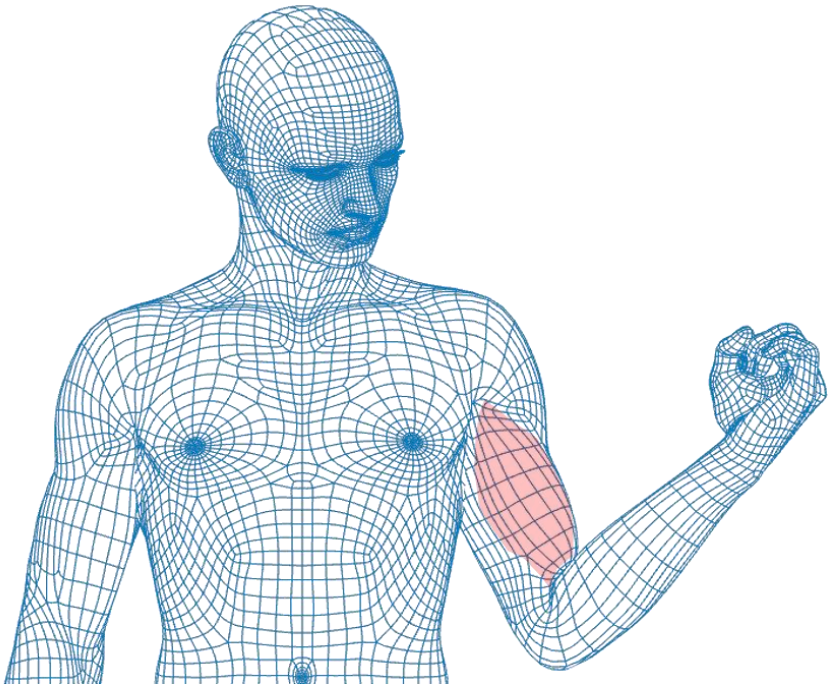


Figure 3: Muscular contraction of the muscle biceps brachii (marked in red) while performing flexion of the elbow, forearm in supination.

An example signal acquisition with the assembled version on the muscle biceps brachii is illustrated in Figure 6.

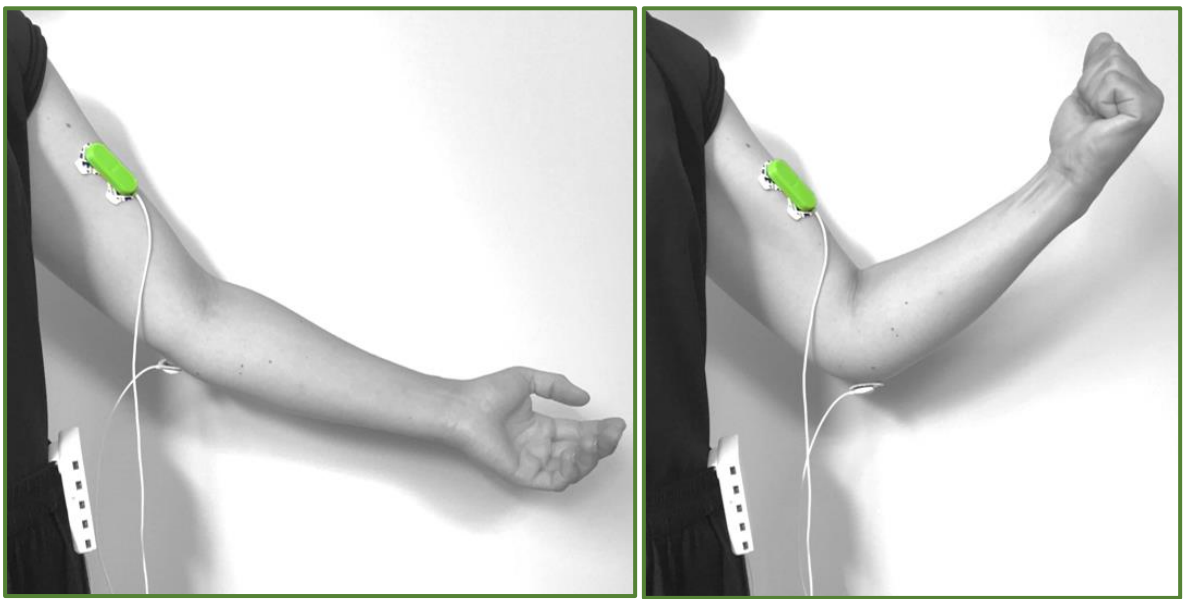


Figure 6: Data acquisition and sensor placement with the assembled BITalino EMG sensor on the muscle biceps brachii.

3. Using the EMG Sensor with BITalino & OpenSignals

The connection of BITalino EMG sensors is demonstrated with the three main Boards with Bluetooth (BT) connection. Notice, that the connection is the same for the Bluetooth low energy (BLE) boards.

3.1. Connecting the sensor to BITalino Systems (BT)

3.1.1. BITalino (r)evolution Board

The BITalino EMG sensor comes already connected to the BITalino (r)evolution Board.

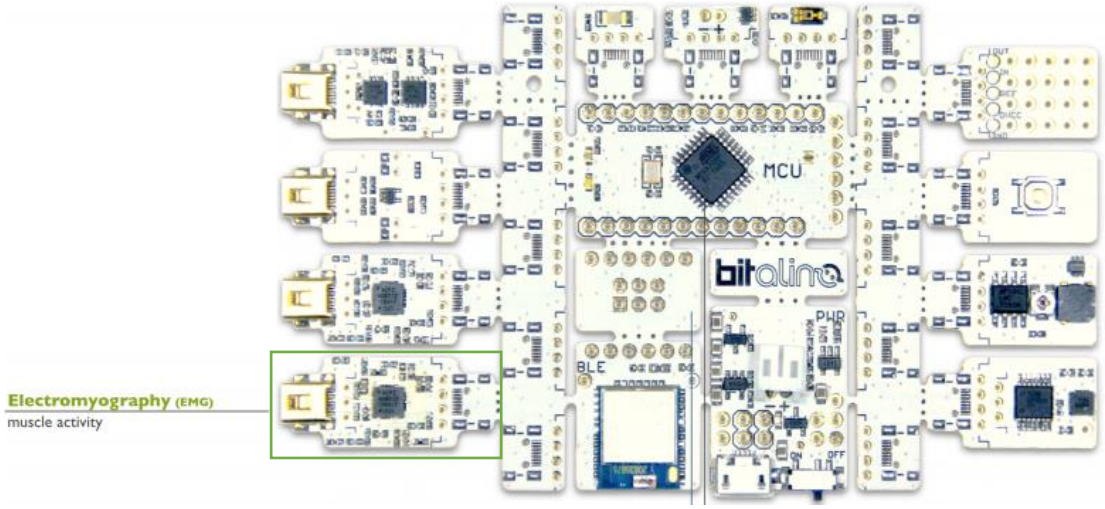


Figure 4: EMG compatible BITalino (r)evolution Board pre-connected to an EMG sensor with UC_E6 connector on one side.

3.1.2. BITalino (r)evolution Plugged

The BITalino EMG sensor (UC-E6 sockets) is compatible with all 6 analog input channels of the BITalino (r)evolution Plugged with a sensor cable with UC-E6 connectors.

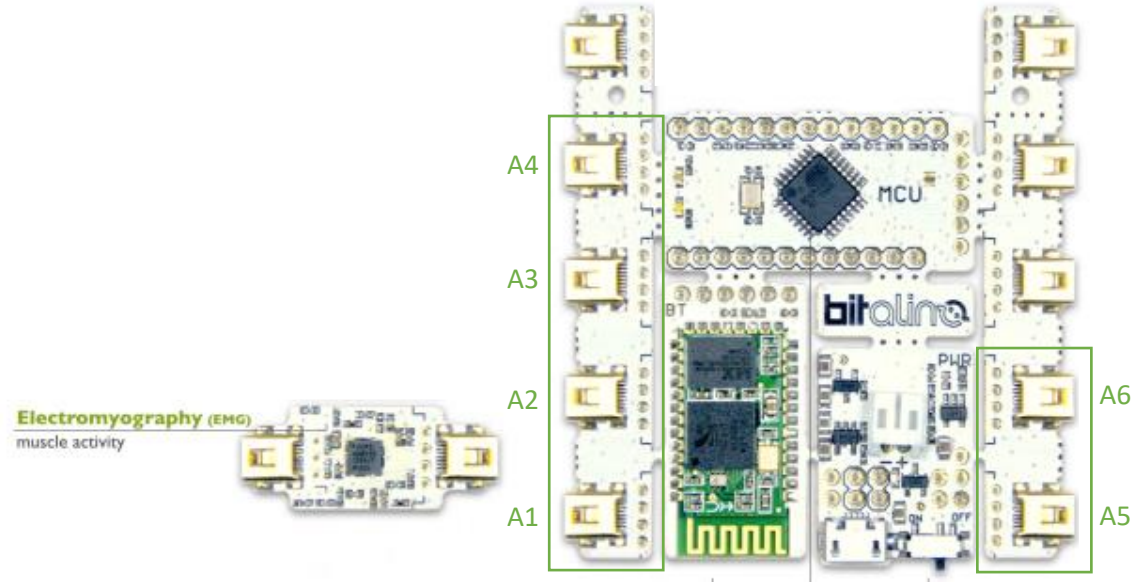


Figure 5: BITalino (r)evolution Plugged with possible connection ports (marked in green) for the EMG sensor (UC-E6).

3.1.3. BITalino (r)evolution Freestyle

The BITalino EMG sensor (no connections or Molex Sherlock plugs) is compatible with the BITalino (r)evolution Freestyle.

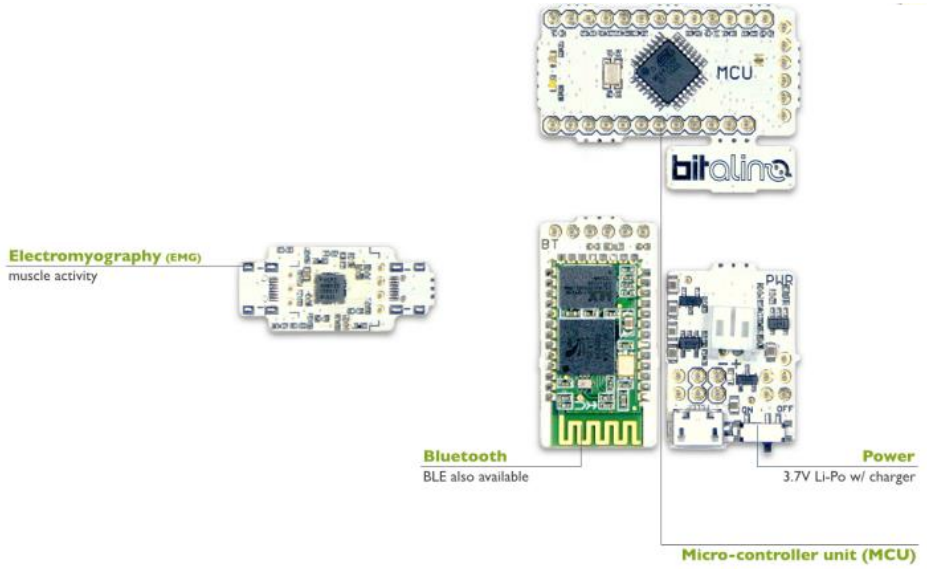


Figure 6: BITalino (r)evolution Freestyle with the possible connection ports (marked in green) for the EMG sensor (without connections) using the Molex Sherlock plugs and sockets or self-mounted cables.

3.1.4. BITalino (r)evolution Core (assembled)

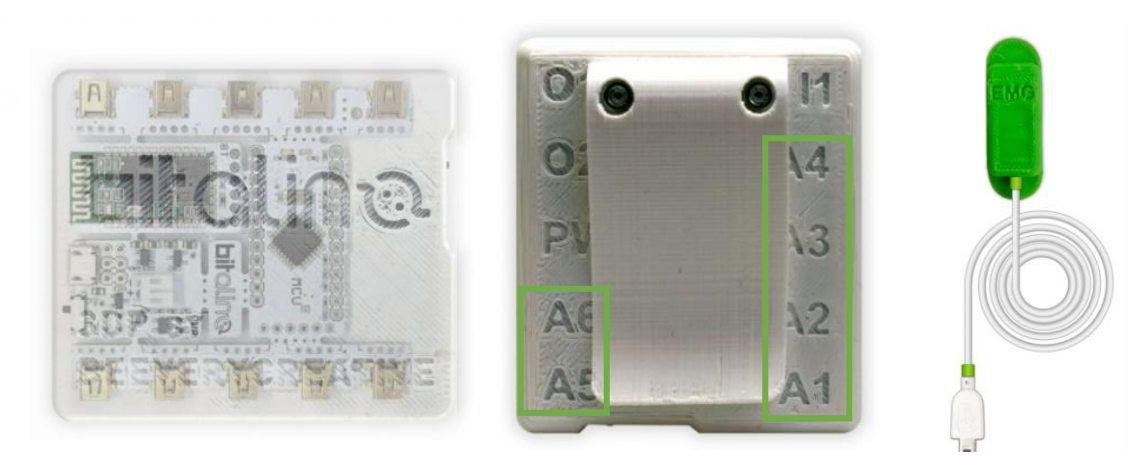


Figure 7: BITalino (r)evolution Core (assembled) and the connection ports for the EMG sensor (assembled) marked in green.

The BITalino EMG sensor (assembled) is compatible with all 6 analog input channels of the BITalino (r)evolution Core (assembled) with a pre-connected sensor cable.

3.2. Configuring the Sensor in OpenSignals

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

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

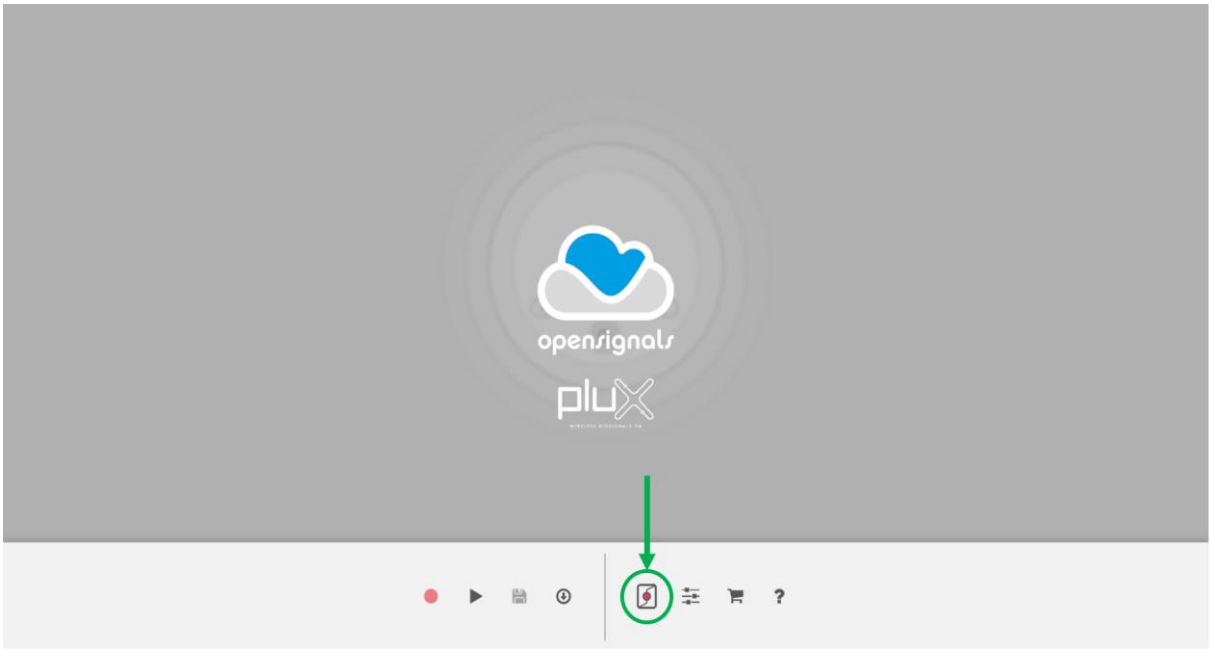


Figure 8: Access the OpenSignals (r)evolution device manager.

Select the device you intend to use for acquisition by clicking on *ENABLE button on* the device panel in the OpenSignals device manager. The device is activated for acquisition if the *ENABLE* button is blue.

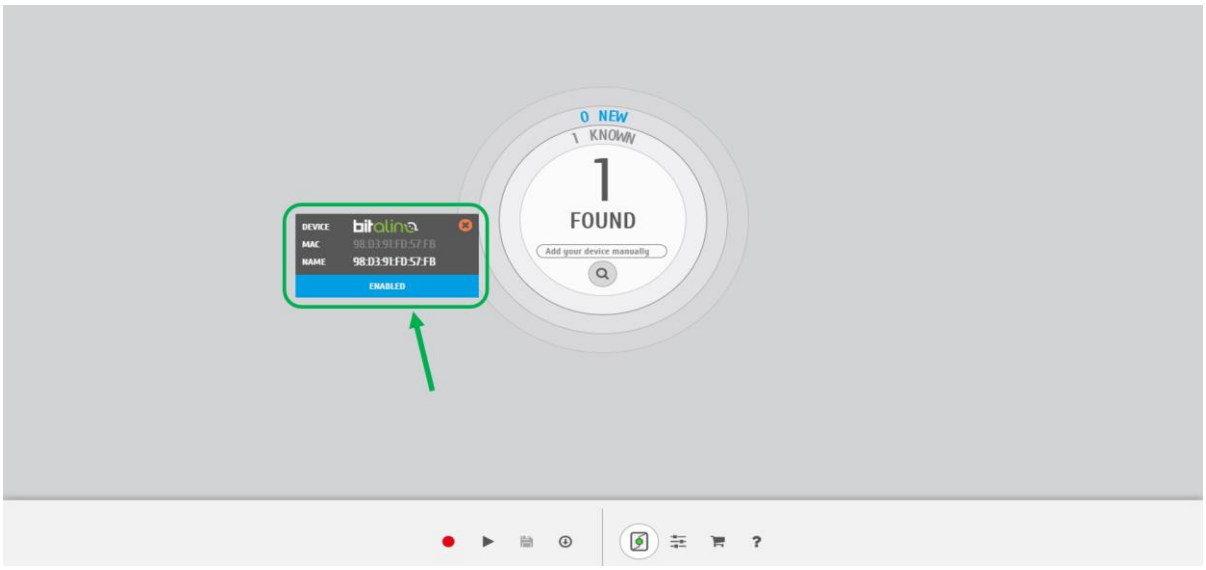


Figure 9: Enabling the device for acquisition.

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

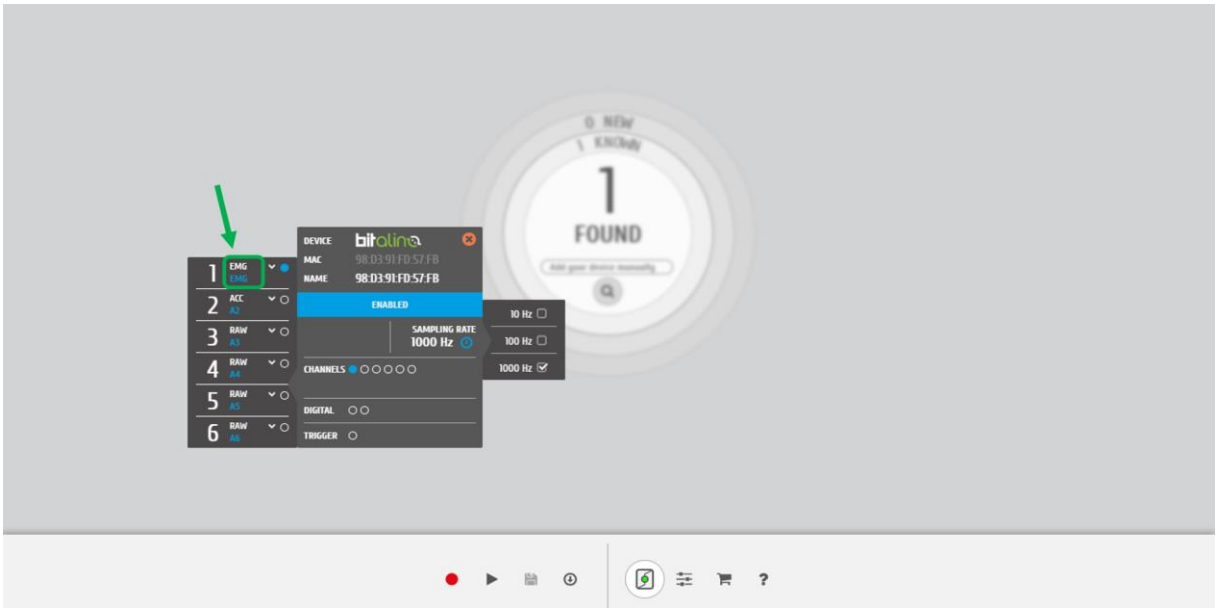


Figure 10: Set the channel type of the channel you have your EMG sensor connected to, to *EMG*.

Activate the channel for acquisition by clicking on the circle next to the channel type (must be blue). If not done before, follow the instruction available in section *2 Application Notes* to learn how to apply the sensors and *3.1 Connecting the sensor to BITalino Systems* to learn how to connect your device to your BITalino device. Click on the record button in the OpenSignals main interface whenever you're ready for your acquisition.

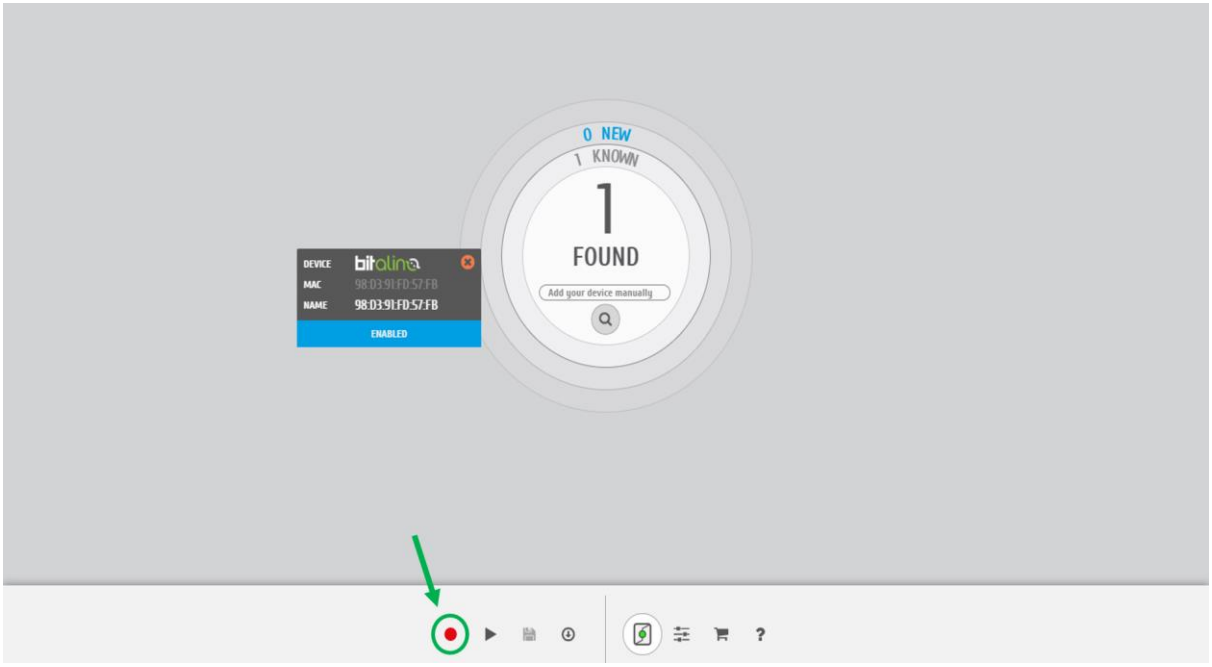


Figure 11: Start the acquisition whenever you're ready.

4. Scientific Publications Using the EMG Sensor

The following scientific is only a small selection extracted from the list of available publications using BITalino. Please visit the following website to access the entire up-to-date list:

https://bitalino.com/en/community/publications

Publications

N. Azman, M.K.B. Novi, et al. "Insomnia analysis based on internet of things using electrocardiography and electromyography." *Telkomnika* 18.3, 2020.

T. Günaydin, R.B. Arslan. "LOWER-LIMB FOLLOW-UP: A Surface Electromyography Based Serious Computer Game and Patient Follow-Up System for Lower Extremity Muscle Strengthening Exercises in Physiotherapy and Rehabilitation." *2019 IEEE 32nd International Symposium on Computer-Based Medical Systems (CBMS)*. IEEE, 2019.

V. GUSSEY, A. VERAKSITŠ, and M. REINVEE. "Feasibility of a Low-cost Microcontroller Based Lumbar Flexion-relaxation Phenomenon Monitoring System." *DEStech Transactions on Social Science, Education and Human Science* ise, 2018.

E. Galido, et al. "EMG Speed-Controlled Rehabilitation Treadmill With Physiological Data Acquisition System Using BITalino Kit." *2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*. IEEE, 2018.

M. Reinvee, and B. Mrugalska. "Contemporary Low-Cost Hardware for Ergonomic Evaluation: Needs, Applications and Limitations." *International Conference on Applied Human Factors and Ergonomics*. Springer, Cham, 2018.

C. Koné. *Architecture logicielle et matérielle d'un système de détection des émotions utilisant les signaux physiologiques. Application à la mnémothérapie musicale*. Diss. 2018.

J. Marques, et al. "Study of Mechanomyographic Alternatives to EMG Sensors for a Low-Cost Open Source Bionic Hand." *EAI International Conference on IoT Technologies for HealthCare*. Springer, Cham, 2018.

T. Günaydin, et al. "A surface electromyography based serious game for increasing patient participation to physiotherapy and rehabilitation treatment following anterior cruciate and medial collateral ligaments operations." *2018 IEEE 31st International Symposium on Computer-Based Medical Systems (CBMS)*. IEEE, 2018.

K. Kutt, et al. "Towards the development of sensor platform for processing physiological data from wearable sensors." *International Conference on Artificial Intelligence and Soft Computing*. Springer, Cham, 2018.

F.T. Putri, et al. "Low cost parkinson's disease early detection and classification based on voice and electromyography signal." *Computational Intelligence for Pattern Recognition*. Springer, Cham, pp. 397-426., 2018

5. Safety & Maintenance

5.1. Safety Instructions

Please read the following safety instructions **before** using your *BITalino* system with the EMG sensor to prevent any damages or problems with the user, test persons and/or *BITalino* devices. Violations of these instructions can lead to inferior signal quality and/or damages to the *BITalino* system and user.

- ! The user should always keep the device and its accessories dry.
- ! The user must turn off the *BITalino* device and contact Technical Support if the system or accessories reach uncomfortable temperatures.
- ! The user should not use the *BITalino* 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 *BITalino* device if experience any kind of discomfort or skin irritation.
- ! Do not use the system on persons with allergies to silver.
- ! The user should dispose detection surfaces after using the *BITalino* device. Detection sur- faces 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 *BITalino* 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 *BITalino* 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 *BITalino* device, nor clean with liquid or abrasives.

! The user should handle the *BITalino* device with caution and not expose the device or accessories to high accelerations and vibrations.

! *BITalino* devices should not be used in patients with implanted electronic devices of any kind, including pace-makers, electronic infusion pumps, stimulators, defibrillators or similar.

! Do not apply electrodes over damaged or irritated skin.

! Do not use your device while charging its internal battery.

5.2. Transportation and Storage

Please follow these recommendations to ensure safe transportation and storage of your *BITalino* equipment and sensors to prevent any damaging of your system.

The *BITalino* equipment and sensors should be stored in the original box in a dry place when those are not being used.

- Relative humidity: up to 95% with no condensation
- Ambient temperature: 10°C to 30°C
- Atmospheric pressure between 500hPa and 1060hPa

Whenever the equipment needs to be transported, it should be placed in the original box, since this was designed and tested to ensure the equipment and accessories are securely stored.

Take care while handling the transportation of the system and avoid dropping it, since the device is not shock-proof and should not be placed under stress or sudden acceleration.

5.3. Cleaning

Please follow these cleaning instructions to prevent any damage of the system or the user because of conducting cleaning methods that may cause any damage.

- The *BITalino* and sensors should be visually checked before each use and cleaning process to ensure that no mechanical damage occurred.

- The *BITalino* equipment and sensors (including the cables) should be cleaned with a slightly damp cloth or suitable absorbent paper, ensuring no liquid enters the equipment of sensors. Do not use detergent or any type of cleaning liquid as these may damage your equipment and/or sensor.

- Do not clean or re-use detection surfaces (electrodes). They are only suitable for single use, and should be disposed of after usage except indicated otherwise.

6. Ordering Guides, Regulatory & Legal Information

6.1. Ordering Guide

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

EMG Sensor

SKU Reference	PLUX Code	UPC
SENS-EMG-UCE6 **SENS-EMG-NC** **SENS-EMG-SHER**	810121202	**641945958829**
Description		
Purpose-built sensor for muscle activity measurement		

Electrodes & Accessories

For a full list of available and compatible electrodes, please visit the BITalino store.

6.2. Guarantee of Quality & Warranty

BITalino sensors have three months quality guarantee from the date of purchase. PLUX guarantees that the system, sensors and accessories will be free from material or manufacturing defects for the mentioned time periods following date of purchase.

If PLUX receives notification of any such defects within the guarantee period, it will repair or substitute with the same unit\model, any products with proven defects at no cost to the client. During the repair period PLUX promises to provide a temporary replacement under the same specification. Repairs will be carried out at PLUX's premises after the equipment has been received.

6.3. Warranty Voidance

Usage of the device that is not in accordance with the handling instructions indicated in the manual, or use with accessories other than those manufactured by PLUX will invalidate the warranty of your devices.

Be careful when connecting your BITalino devices, sensors and/or accessories to any third party device including the usage of the 3rd party connection components that are available for BITalino systems as **the usage of these components will void the electrical warranty of your BITalino device and sensors and, if not indicated otherwise, the warranty of the 3rd party system you're connecting to the device**. Check the electrical specifications of both systems you want to connect to prevent any damage of the user(s) or the systems.

In the case of warranty voidance, the same applies that we expressly disclaim any liability whatsoever for any direct, indirect, consequential, incidental or special damages, including, without limitation, lost revenues, lost profits, losses resulting from business interruption or loss of data, regardless of the form of action or legal theory under which the liability may be asserted, even if advised of the possibility of such damages.

6.4. Contact & Support

Contact us if you are experiencing any problems that cannot be solved with the information given in the BITalino documentation.

Please send us an e-mail with precise information about the error occurrence, device configuration, and, if possible, screenshots of the problem to support@plux.info.

6.5. Regulatory Disclaimer

BITalino products are intended for use in life science education and research applications; they are not medical devices nor are they intended for medical diagnosis, cure, mitigation, treatment or prevention of disease. we expressly disclaim any liability whatsoever for any direct, indirect, consequential, incidental or special damages, including, without limitation, lost revenues, lost profits, losses resulting from business interruption or loss of data, regardless of the form of action or legal theory under which the liability may be asserted, even if advised of the possibility of such damages.

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